Vegetation and Fuel Dynamics Following Clearfelling of Dry Eucalypt Forests on Dolerite in Southeastern Tasmania With Special Reference to the Use of Fire in Forest Regeneration.

by

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university and contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text.

Katharine Dickinson

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ABSTRACT

In order to supply eucalypt pulpwood to an expanding woodchip industry the silvicultural management practice of clearfelling followed by slash-burning was adopted in the dry eucalypt forests on dolerite in southeastern Tasmania.

To provide data on the vegetation and fuel dynamics following dry forest utilisation, a study area with comparable sites that were (a) unlogged, (b) clearfelled, (c) clearfelled and slash-burned, was monitored over a 24 month period. Detailed records were made of plant species composition and cover on floristically similar permanent plots on each of these sites. Fuel levels, fuel structure and fuel composition were measured at the study area, and at other East Coast sites of varying ages since slash-burning. A monthly bird census was conducted in the main experimental area to establish the inter-relationships of the avifauna with particular plant species and habitats.

Following clearfelling there was found to be marked variation in the growth response of plant species, due to environmental situation, degree of disturbance, and intensity of slash-burn. Moreover, the effect of these factors on individual species was greatly influenced by selective grazing and browsing, predominantly by native fauna. The combination of burning and predation tended to favour unpalatable species which recovered rapidly by vegetative means.

The succession of plant species following fire in dry forest communities most closely approximated the initial floristic composition model. Most of the plant species recovered rapidly with a progressive increase in species richness for at least two years after disturbance.

Slash-burning was found to reduce the levels of fine fuel ($<$2.0cm in diameter or thickness) left as a result of clearfelling, but the practice was ineffective in reducing the volume of coarse fuel ($\geqslant$2.0cm in diameter or thickness). However, over time, this relative reduction

of fine fuel was only persistent in the compacted ground fuel layer, as the regenerating stand rapidly recovered the above-ground, vertical fine fuel structure.

Experiments were conducted on various dry forest and wet forest plant species and fuel components, in order to establish their energy content and relative flammability. It was found that eucalypt dry forest species and fuel components had the highest energy content and the greatest tendency to propagate fire, whereas species from wet forest and *Casuarina* dry forest communities propagated fire less readily. Species from dry habitats had, in general, low ash contents, high energy levels, high volatile oil contents and low moisture contents. Wet habitat species had high percentages of moisture and ash. As a result, general support could be given to the hypothesis that natural selection has favoured flammable characteristics in fire-dependent plant communities.

The gains from the retention of natural eucalypt regeneration after clearfelling (i.e. forest management in the absence of hot, slash-burns) may generally offset the short-term advantage of reduced fire hazard which results from slash-burning.

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GLOSSARY OF TERMS AND ABBREVIATIONS

TERMS (N.B. underlining indicates that the term is defined elsewhere in the glossary)

Advanced growth.............. Non-merchantable eucalypt stems at time of logging but of potential merchantable value.

Advanced natural regeneration.............. Synonymous with advanced growth.

Artificial regeneration...... Eucalypt regrowth resulting from manual or aerial sowing of seed.

Back-burn.................... A planned burn in the path of a wildfire, with the aim that when the unplanned fire spreads to the particular area which has been purposely burnt the lack of fuel will enable the wildfire to be controlled.

Broadcast burning............ The planned burning of a large area, generally with the intention of inducing fire of high intensity.

Clearfelling................. The logging of all merchantable trees in a coupe.

Coarse fuel.................. All dead material $\geqslant$2.0cm in diameter or thickness.

Concession................... An area of land for which licences are issued giving exclusive rights to the licence-holder for the exploitation of specified forests.

Control(led) burn............ A form of prescribed burn. A planned, deliberately lit fire, generally of low to medium intensity aimed at reducing fuel loads and therefore also the accompanying risk of uncontrollable wildfire.

Coupe........................ The basic forestry unit of area, within which trees are felled. In Tasmania the areas covered generally range from 200-400 ha.

Cull......................... Tree left standing following logging, generally because it is of insufficient quality to be harvested.

Decorticating bark.......... Bark which peels or flakes from a tree trunk.

Dry forest.................. Forests which have open understories dominated by various combinations of scleromorphic shrubs, tussock grasses, bracken and tussock graminoids.

Even-aged................... Consisting of trees of the same age.

Fine fuel................... All dead material <2.0cm in diameter of thickness.

Fire hazard................. A term generally used to describe the fuel levels in a particular area and their potential for contributing to an uncontrollable fire.

Fire protection period...... A period when fuel levels are so low on a particular area that fire cannot carry.

Fuel reduction burn......... see <u>control burn</u>.

Hazard reduction burn....... see <u>control burn</u>.

Lignotuber.................. A woody basal stem swelling possessed by many small eucalypt plants which acts as a source of buds and food.

Live fuel................... The living biomass.

Logging..................... The felling and subsequent removal of trees.

Log landings................ Areas within a <u>coupe</u> to which cut logs are hauled, to be loaded onto trucks.

Macro-plot.................. see <u>macro-quadrat</u>.

Macro-quadrat............... A term used to describe the 5m x 5m permanent plots which were monitored on the main study area at Mt. Morrison.

Mechanical disturbance...... Disturbance generally involving the use of machinery to expose the mineral soil.

Prescribed burn............. A planned fire lit to burn an area at a particular time and with a particular intensity.

Private forest.............. Forest owned by private landholders.

Protection forest............	High quality regrowth forest, probably with good potential for producing a sawlog crop.
Pulpwood......................	Low quality wood suitable for pulp or woodchips.
Regeneration..................	The young vegetation regrowing on a site following forest utilisation.
Regeneration burn............	see slash-burn.
Regrowth......................	see regeneration.
Reserve.......................	An area of land reserved for a particular concession licence-holder for which the holder may ultimately be given rights to forest exploitation.
Rotation cycle...............	The elapsed time between one forest harvest and the next on the same site.
Sap rings.....................	The exuding of sap, as a result of which the sap is incorporated into the growth rings of the tree. The discharge may be a response to damage from such causes as fire, disease or insect attack.
Sawlog........................	High quality wood suitable for sawmilling.
Selective logging............	Logging using various selection criteria resulting in the removal of only a proportion of the merchantable trees at any one particular time.
Slash.........................	Residue left following logging consisting of the unwanted lopped branches, twigs, leaves, etc.
Slash-burn....................	A form of prescribed burn lit following clearfelling with the intention of causing a hot, intense fire to reduce fire hazard and create a suitable seed-bed for eucalypt establishment.
Snig track....................	Tracks left as a result of log haulage.
Standing tree.................	see cull.
State Forest..................	Forest which is government-owned.

Subplot........................ see <u>subquadrat</u>.

Subquadrat..................... A term used to describe the 1m x 1m quadrats into which the 5m x 5m permanent quadrats were divided as part of the recording on the main study area at Mt. Morrison.

Uneven-aged.................... Consisting of trees of different ages.

Wet forest..................... Forest with understories dominated by broad-leaved shrubs, small trees and ferns.

Wildfire....................... Unplanned fire.

ABBREVIATIONS

AB............................. Above-ground elevated bark.

ADV............................ Above-ground elevated dead herbaceous vegetation (consisting of the leaves, culms, inflorescences, fronds and foliage of herbs, graminoids, grasses and ferns).

A/GD........................... Above-ground elevated dead material.

AGDT........................... Combined total weight of all elevated fine dead material.

A/GL........................... Above-ground elevated live material.

ALE............................ Above-ground elevated dead leaves.

AT1............................ Above-ground elevated dead twigs <0.5 cm in diameter or thickness.

AT2............................ Above-ground elevated dead twigs 0.5-1.0 cm in diameter or thickness.

AT3............................ Above-ground elevated dead twigs 1.0-1.5 cm in diameter or thickness.

AT4............................ Above-ground elevated dead twigs 1.5-2.0 cm in diameter or thickness.

Control C...................... The non-clearfelled mature forest studied at Mt. Morrison.

GB............................. Dead bark in the ground layer.

GDT.......................... The combined total weight of all the fine dead material present in the ground layer.

GDV.......................... Ground dead herbaceous vegetation (see ADV).

GL........................... Live material present in the ground layer.

GLE.......................... Dead leaves in the ground layer.

GMF.......................... Miscellaneous fine dead material obtained after sieving to remove soil and charcoal contamination.

GT1.......................... Dead twigs <0.5 cm in diameter or thickness in the ground layer.

GT2.......................... Dead twigs 0.5 - 1.0 cm in diameter or thickness in the ground layer.

GT3.......................... Dead twigs 1.0 - 1.5 cm in diameter or thickness in the ground layer.

GT4.......................... Dead twigs 1.5 - 2.0 cm in diameter or thickness in the ground layer.

K-W.......................... Kruskal-Wallis one-way analysis of variance.

MM14......................... The main study area, the coupe Mt. Morrison block, compartment 14.

MM20......................... The clearfelled coupe in vegetation types P and O; Mt. Morrison block, compartment 20, which was regenerated by slash-burning and aerial sowing of seed in 1978.

M-W.......................... Mann-Whitney U Test.

p = ... Significance level. Differences are significant at all levels of probability less than or equal to the level given (p = 'x') in the particular part of the text or illustration.

Plot 1
" 2.......................... The two permanent plots chosen in each vegetation type, treatment and control in the main study area at Mt. Morrison.

r_s.......................... Spearman rank correlation coefficient.

Selection 1
" 2.................. The two selections of permanents plots made for each vegetation type in the main study area at Mt. Morrison. Floristically similar plots were chosen from the clearfelled area which was slash-burnt, the clearfelled area which was left unburnt, and from the non-clearfelled mature forest.

TO2.......................... The clearfelled coupe in vegetation types P and O; Tooms block, compartment 2 which was regenerated by slash-burning and aerial sowing of seed in 1974.

TO30......................... The high altitude clearfelled coupe in vegetation type D/O; Tooms block, compartment 30. Part of the coupe was left unburnt following clearfelling, the rest was slash-burnt and aerially sown with seed in 1975.

TO56......................... The high altitude clearfelled coupe in vegetation type D/O; Tooms block, compartment 56. Part of the coupe was left unburnt following clearfelling, the rest was slash-burnt and aerially sown with seed in 1976.

Treatment B.................. The area of the main study site at MM14 which was clearfelled in 1981, slash-burnt and aerially sown with seed in 1982.

Treatment UB................. The area of the main study site at MM14 which was clearfelled in 1981, but was not slash-burnt or aerially sown with seed in 1982.

Type D/O..................... Dry forest dominated by <u>Eucalyptus delegatensis</u> and <u>E. obliqua</u>.

Type O....................... One of the two major vegetation types found in the dry forests on dolerite in southeastern Tasmania; forest dominated by <u>E. obliqua</u>.

Type P....................... One of the two major vegetation types found in the dry forests on dolerite in southeastern Tasmania; forest dominated by <u>E. pulchella</u>.

CHAPTER 1

INTRODUCTION

The native vegetation of Tasmania covers 82% of the State's total area of approximately 6,620,000 ha. Fifty-three percent of this vegetation consists of forest communities which are dominated by eucalypts (Kirkpatrick and Dickinson, 1984). In turn, 41.3% of these eucalypt forests may be broadly defined as wet, and 58.7% as dry (Table 1). Wet forests have understories dominated by broad-leaved shrubs, small trees and ferns, whereas the understories of dry forests are dominated by various combinations of scleromorphic shrubs, tussock grasses, bracken and tussock graminoids (Table 1).

Of the total area of government-owned State Forest, 1,180,000 ha, 56.6% lies in the highly productive wet forest communities, which are mainly dominated by *Eucalyptus obliqua* and *E. regnans*. However, only 21% of the total private forest holding of 1,500,000 ha, occurs in the wet forest categories.

The dry forests comprise a large proportion of both State and private land, and have been subject to a great degree of clearance over the last decade (Kirkpatrick and Dickinson, 1982). However, significantly less is known of their ecology and silviculture than of the wet forest types. Some research has been undertaken in the dry forests dominated by *E. delegatensis* (Needham, 1960; Orme, 1971; Bowman, 1984; Bowman and Kirkpatrick, 1984) and in the sclerophyll forest communities (Duncan, 1981a). Nevertheless, the grassy forests remain largely unstudied except in a descriptive context (Hogg and Kirkpatrick, 1974; Wells *et al*., 1977; Brown and Bayley-Stark, 1979; Kirkpatrick *et al*., 1980, Kirkpatrick, 1981; Harris and Kirkpatrick, 1982).

TABLE 1 SUMMARY OF EUCALYPT FOREST CATEGORIES IN TASMANIA, TOGETHER WITH GENERAL VEGETATION DESCRIPTIONS AND LAND TENURE STATISTICS AFTER KIRKPATRICK & DICKINSON (1984).

W = wet forest D = dry forest

Vegetation mapping unit	Description	Area of Unit (ha)	Area of Unit in State Forest (ha)	Area of Unit on Private Property (ha)	% area of Unit in State Forest	% area of Unit on Private Property	% of total euc. forest area in each Unit	% of total State Forest area in each Unit	% of total Private Property area in each Unit
E. simmondsii wet forest, W	Usually dominated by E. simmondsii. Wet scrub or rainforest understorey.	145,794	10,191	11,381	7.0	7.8	5.1	0.9	1.0
E. obliqua wet forest, W	Mainly dominated by E. obliqua to 40m ht. Dense rainforest or scrub understorey.	537,023	279,825	171,003	52.1	31.8	18.7	23.8	14.8
E. obliqua tall forest, W	>40m ht, dominated by E.obliqua & E.regnans. Dense rainforest or scrub understorey.	360,479	281,287	44,736	78.0	12.4	12.6	23.9	3.9
E.delegatensis tall forest, W	>40m ht, dominated by E. delegatensis. Rainforest, scrub or tussock grassland understorey.	119,150	89,784	11,152	75.4	9.4	4.2	7.6	1.0
E. simmondsii scrub, W	Open-scrub/open forest dominated by E. simmondsii. Heath understorey.	21,152	5,062	3,427	23.9	16.2	0.7	0.4	0.3
E. delegatensis dry forest, D	To 40m ht. Variable understorey mostly of tussock grasses, sclerophyll shrubs and broad-leaved shrubs.	498,643	223,502	168,069	44.8	33.7	17.4	19.0	14.6
Coastal grassy forest, D	Dominance variable between E.globulus, E.pulchella, E.obliqua, E.amygdalina, E.tenuiramis, E.ovata. Understorey of tussock grasses and small shrubs.	268,095	66,589	176,339	24.8	65.8	9.4	5.7	15.3
Inland grassy forest, D	Dominants -E.viminalis, E,ovata, E.pauciflora & E.amygdalina. Tussock grass understorey.	227,837	55,486	218,271	20.0	78.6	9.7	4.7	15.9

TABLE 1 Continued

SUMMARY OF EUCALYPT FOREST CATEGORIES IN TASMANIA, TOGETHER WITH GENERAL VEGETATION DESCRIPTIONS AND LAND TENURE STATISTICS AFTER KIRKPATRICK & DICKINSON (1984).

W = wet forest D = dry forest

Vegetation mapping unit	Description	Area of Unit (ha)	Area of Unit in State Forest (ha)	Area of Unit on Private Property (ha)	% area of Unit in State Forest	% area of Unit on Private Property	% of total euc. forest area in each Unit	% of total State Forest area in each Unit	% of total Private Property area in each Unit
Montane grassy forest, D	Dominants - E.rodwayi, E.pauciflora & E.dalrympleana. Tussock grass understorey.	48,703	10,304	21,472	21.2	44.1	1.7	0.9	1.9
Inland E.tenuiramis dry forest, D	Open-scrub/open-forest dominated by E.tenuiramis. Sparse to dense scleromorphic shrub understorey.	101,428	6,234	91,122	6.1	89.8	3.5	0.5	7.9
Coastal E.tenuiramis dry forest, D	Open scrub/open forest dominated by E.tenuiramis. Shrub understorey.	10,628	896	1,294	8.4	12.2	0.4	0.1	0.1
E.sieberi dry forest, D	To 40m ht. Usually pure stands E.sieberi. Very sparse understorey.	75,468	58,248	14,252	77.2	18.9	2.6	5.0	1.2
Sclerophyll forest, D	Dominants - E.amygdalina, E. obliqua, E.viminalis & E.ovata. Closed heath or bracken understorey.	384,745	79,849	213,882	20.8	55.6	13.4	6.8	18.6
E.amygdalina dry forest, D	Dominants-E.amygdalina, E.viminalis, E.obliqua. Sparse to very sparse understorey.	17,099	8,254	6,112	48.3	35.7	0.6	0.7	0.5
	Total Eucalypt Forest Area	2,866,244	1,175,511	1,152,512					

Exploitation of the Tasmanian dry forests for woodchips began in 1971 with the provision of both a ready market in Japan and a processing mill at Triabunna (Fig. 1).

The majority of the dry forests in Tasmania lie in the East Coast forest concession held under licence by Tasmanian Pulp and Forest Holdings (TPFH: Fig. 1), now a subsidiary of Australian Pulp and Paper Manufacturers Ltd. (APPM). The licence, negotiated under the 1968 Pulpwoods Products Industry (Eastern and Central Tasmania) Act gives the exclusive rights to all eucalypt pulpwood in State Forest covering 281,200 ha (Bowman, 1981a).

Dry forest exploitation preceded research into the management of these communities, and in the presence of both market and demand, the industry adopted practices used in the ecologically better known wet forests of the State.

Research into the ecology and silvicultural management of wet forests dominated by even-aged eucalypts has taken place over several decades (e.g. Gilbert, 1958, 1959; Cunningham, 1960; Cremer and Mount, 1965; Cremer, 1969; Gilbert and Cunningham, 1972; Evans, 1978). The current procedure (termed clearfelling) involves the logging of all merchantable trees over large areas (known as coupes) typically 200-400 ha in size. Clearfelling is followed by broadcast burning of slash (the residue left after logging operations), and aerial sowing of seed. Fire is used to provide a suitable seed-bed for eucalypt establishment and regeneration. Burning increases the available light at ground level, induces a flush of nutrients and reduces competition for moisture. The combined result has been termed the ash-bed effect (Pryor, 1960, 1963). In the absence of clearfelling, most regeneration of the eucalypt forest occurred after intense wildfires created a suitable seed-bed and caused seed release from adult trees.

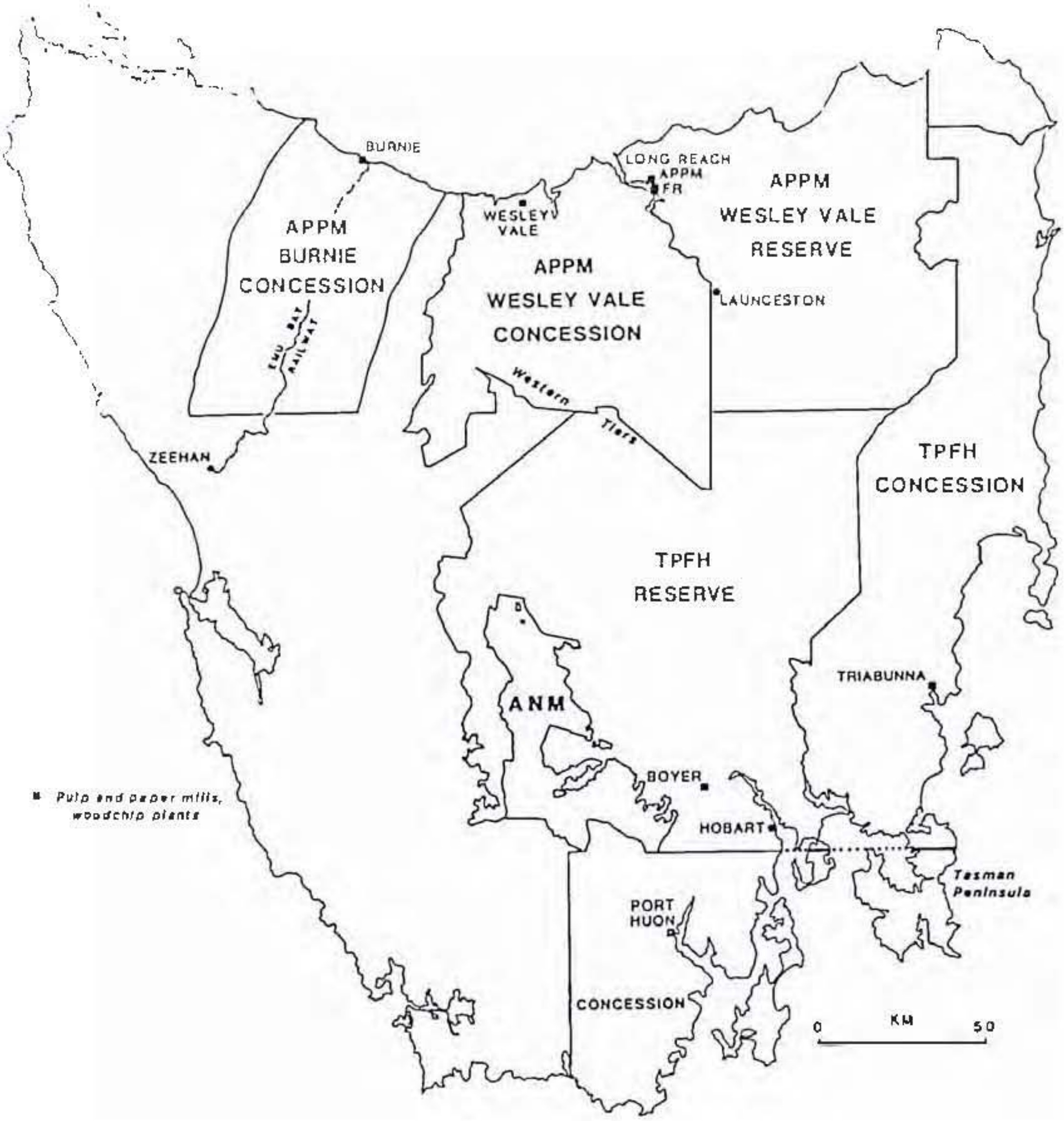


Fig. 1 : Map of the pulpwood concession areas in Tasmania together with the location of the pulp and paper mills and woodchip plants.

Note : The area marked CONCESSION was formerly under licence to Australian Paper Manufacturers Ltd. (APM) but is currently under review. The Port Huon mill is presently closed. The Tasman Peninsula was formerly the APM Reserve area.
Of the RESERVE areas marked on the diagram, only the APPM Wesley Vale Reserve has been allocated so far.

ANM = Australian Newsprint Mills Ltd.; APPM = Australian Pulp and Paper Mills Ltd.; FR = Forest Resources; TPFH = Tasmanian Pulp and Forest Holdings.

However, the practice of clearfelling and slash-burning in Tasmanian wet forests has come under increasing scrutiny in recent years, with ongoing debate concerning site deterioration (Harwood and Jackson, 1975; Raison, 1980, 1981; Turner and Lambert, 1980; Bowman, 1981b; Nielsen and Ellis, 1981; Felton, 1982; Jackson and Bowman, 1982).

Concern has also been expressed that the management technique is inappropriate for the dry forest ecosystem, where the understories are open and the eucalypts uneven-aged (Bowman and Jackson, 1981; Kirkpatrick and Bowman, 1982).

Some silviculturalists state that slash on dry forest sites is at present burned only for fire protection reasons (Lockett and Candy, 1984). There are few data concerning the effects of fire on fuel levels, fuel structure, fuel assemblages or fuel dynamics in the clearfelled dry forests to substantiate or refute this reasoning.

Similarly, there are few data on the impact of clearfelling or slash-burning on vegetation dynamics in eastern Tasmania. Duncan (1981a) studied regeneration and species diversity in sclerophyll forest communities (Table 1) on sandstone, but the vegetation types occurring on the dominant country rock, dolerite, (coastal grassy forest: Table 1) were unstudied.

Some of the disadvantages of slash-burning have been outlined by Felton (1976). The main short-term considerations lie in the loss of advanced eucalypt regeneration (non-merchantable stems at the time of logging, but of potential merchantable value), loss of on-site eucalypt seed, and possible site deterioration due to nutrient depletion and erosion. Doubts have also arisen concerning the reduction of fire hazard, with the young regenerating stand rapidly accumulating fine fuel composed of leaves and twigs (Bowman and Jackson, 1981; Kirkpatrick and Bowman, 1982). It has been suggested that in the absence of fire, suitable seed-bed preparation for eucalypt regeneration may be produced by mechanical disturbance (Felton, 1976).

The small number of days in a year suitable for slash-burning, its relative cheapness as a management tool, the fact that each burn has a risk of escape, and evidence to suggest that browsing by native fauna is lower the larger the unit size, have been the reasons given for the large coupe size currently employed (Gilbert and Cunningham, 1972; Felton, 1976; Mount, 1976). The effects of current dry forest management practices on wildlife, vertebrate and invertebrate, in these species-rich habitats (Guiler, 1965) are poorly known.

Current forest management practice in dry eucalypt forests involves two major disturbances. Firstly, the disturbance caused by the logging operation itself, and secondly the disturbance resulting from slash-burning. On the basis of existing literature it was hypothesised that the combined disturbance of clearfelling and slash-burning would have greater ecological impact than clearfelling alone. However, the nature of this impact could not be predicted.

Disturbance following fire has been shown to affect species diversity (e.g. Duncan, 1981a; Shafi and Yarranton, 1973), species richness (e.g. Dyrness, 1973; Loyn et al., 1983), species demography (e.g. Harper, 1977) and species regenerative mechanisms (e.g. Purdie, 1977a, 1977b). Consequently, a detailed experiment was designed to elucidate the effects of clearfelling alone, and the combined effects of clearfelling and slash-burning, on plant species regeneration, demography and early secondary succession (Chapter 2).

At an early stage it became apparent that grazing and browsing was having a major effect on plant species regeneration, and was affecting, at the very least, short-term succession. Therefore, the experiment was expanded to explore the ecological effects of grazing and browsing on disturbed and undisturbed sites. In addition, the hypothesis was tested that the combination of clearfelling and slash-burning encouraged grazing and browsing (cf. Leigh and Holgate, 1979: Chapter 3).

The vegetation and fuel dynamics of the ecosystem were studied contemporaneously. It was hypothesised that slash-burning increased the flammability of the forest by encouraging dominance and persistence of fire-dependent plant species. As a result, it was important to know which species, if any, were favoured by slash-burning and to measure their flammability characteristics (Chapters 2 and 5).

The argument and controversy surrounding the fire hazard associated with particular clearfelled sites in dry forests has been based on little hard data. This study therefore addressed the following questions:

(a) did slash-burning significantly reduce fire hazard on a clearfelled site compared to an unburnt clearfelled site, and if so for how long did this reduction persist? (Chapters 4 and 6);

(b) how did slash-burning affect the fuel structure, fuel composition and fuel arrangement compared to an unburnt clearfelled site over time, and what implications did these effects have in terms of fire hazard? (Chapters 4 and 6);

(c) if there were differences in fire hazard on burnt and unburnt clearfelled sites what implications did these variations have for eucalypt productivity? (Chapter 6);

(d) could slash-burning be justified in productivity terms considering the loss of advanced growth on unburnt sites? (Chapter 6).

Wildlife is sensitive to disturbance induced by forest practices (e.g. McIlroy, 1978; Statham, 1984). Bird species composition and abundance has been shown to change on clearfelled sites compared to mature forests in locations elsewhere in southeastern Australia (Loyn et al., 1980; Pattemore, 1980). However, the effect of slash-burning has not been specifically addressed in the literature. Therefore, the hypothesis was tested that the combined disturbance of clearfelling and slash-burning would restrict bird species composition and abundance to a greater degree than disturbance following logging alone (Chapter 7).

CHAPTER 2

VEGETATION DYNAMICS FOLLOWING CLEARFELLING

I. REGENERATION, DEMOGRAPHIC CHANGE AND SECONDARY SUCCESSION

2.1 INTRODUCTION

Secondary succession has been described as the process of re-establishment of a reasonable facsimile of the original plant community after a temporary disturbance (Horn, 1974). The transition involves temporal change in both the floristic composition of plant communities and the relative importance of constituent lifeforms.

In classical secondary succession theory the process is seen in terms of relay floristics resulting from interspecific competition. Thus, sequential suites of species progressively establish on a site, each species eventually producing an environment in which other species are competitively superior.

There is usually a marked decline in the rate of floristic change as succession proceeds. Once change becomes slow or ceases then the community is termed the climax. These climax communities, while locally constant, may vary from place to place within a locality in a continuous fashion (Whittaker, 1953).

The generality of the relay floristic interpretation of secondary succession has been questioned by Egler (1954) who preferred a model based on initial floristic composition. In this instance, the longest-lived species present in the initial post-disturbance community become the dominants. However in certain cases, passage to the climax community dominated by trees and shrubs may be truncated if species occurring in the early stages of succession are long-lived and achieve dominance (Connell and Slatyer, 1977).

Various forms of disturbance, and subsequent successional characteristics, have been considered in the ecological literature. For example, floristic change has been studied following the abandonment of previously cultivated areas, termed old-field succession (e.g. Quarterman, 1957; Whitford and Whitford, 1978), and investigations into succession following disturbance by fire is covered by a large diverse literature (e.g. Jarrett and Petrie, 1929; Lemon, 1949; Jackson, 1968; Hanes, 1971; Naveh, 1975; Gimingham et al., 1981; Noble and Slatyer, 1981; DeBenedetti and Parsons, 1984).

In an Australian context, fire has long been recognised as a fundamental environmental force (e.g. Gardner, 1957; Mount, 1964; Gill, 1975; Gill et al., 1981). As such, pyric succession has been studied by a number of workers, for example Purdie and Slatyer (1976), Purdie (1977a, 1977b), Bell and Koch (1980), in dry forests, and Specht et al. (1958), Russell and Parsons (1978) and Posamentier et al. (1981), in heathland communities.

However, successional response following forest utilization involving fire is less well researched. Floristic change resulting from forestry activities has received most attention in North America (e.g. Isaac, 1940; Morris, 1958; Mueller-Dombois, 1965; Dyrness, 1973; Parker and Swank, 1982) where clearfelling, with and without slash-burning, has been practiced for several decades. In Australia, the information that is available for wet forests is greater than that for dry forest communities (see Chapter 1). In the case of the latter, the most substantial works that can be related to the present study have been conducted by Duncan (1981a) in Tasmania (see Chapter 1) and by Loyn et al. (1980) and Loyn et al. (1983) in Victoria. The Victorian research investigated the long-term effects of pulpwood operations on forest habitats in Gippsland. Loyn et al. (1980) studied the flora and fauna in various ages of regeneration whilst Loyn et al. (1983) monitored vegetation change on burnt and unburnt sites through time.

Nevertheless, there has been little research into the impact of forest management techniques on vegetation under different silvicultural treatments, and between floristically similar areas. Austin (1981) notes that studies of changes in spatial patterns of species through time are few, and recommends the detailed simultaneous study of temporal and spatial heterogeneity by use of permanent quadrats. His recommendations include spatially contiguous plots, temporal continuity of recording, replication at different locations, and recording of individual plants for determination of plant demography.

This chapter discusses temporal change in dry forest communities on dolerite in southeastern Tasmania, following forest utilization. An experiment was designed involving the use of permanent quadrats (cf. Austin, 1981) in order to establish the ecological impact of disturbance by clearfelling, and by clearfelling plus slash-burning. Permanent quadrats were established on burnt and unburnt clearfelled treatments, as well as on non-clearfelled control sites in dry eucalypt forest types typical of those found on dolerite in eastern Tasmania. The permanent plots were monitored in detail to discover the effects of fire intensity on early secondary succession; the demography of certain plant species following fire; and the changes in species cover, diversity and richness over time. In addition the hypotheses were tested that slash-burning:

(a) created a suitable seed-bed for eucalypt establishment;

(b) rapidly increased the height, basal area and density of eucalypt regeneration in comparison to unburnt clearfelled sites.

2.2 THE STUDY AREA

2.2.1 Site selection

Field investigation of dry forest sites on dolerite was conducted during winter 1981. The coupe, Mt. Morrison block, compartment 14 (hereafter referred to as MM14) satisfied the main criteria for selection:

1) It contained the two major vegetation types found in dry forest communities on dolerite in southeastern Tasmania;

(a) those dominated by *Eucalyptus obliqua* (hereafter referred to as type O), and

(b) those dominated by *E. pulchella* and *E. amygdalina* (hereafter referred to as type P).

2) It had suitable fire protection boundaries and coupe configuration to allow part of the coupe to be burnt, and to provide the maximum possible protection from fire for the area to be left unburnt.

3) It was readily accessible from Hobart (Fig. 2).

2.2.2 Experimental design

The O and P vegetation types at MM14 were both treated by;

(a) clearfelling followed by slash-burning (hereafter referred to as treatment B), and

(b) clearfelling without slash-burning (hereafter referred to as treatment UB), (Plate 1).

In addition, untreated control areas (hereafter referred to as control C) which were similar to type P, and to type O were selected (Fig. 3).

The control areas consisted of mature forest which had been cutover for sawlog timber for several decades but were not treated by clearfelling. An uncut portion of the forest present at MM14 provided the *E. obliqua* dominated control site (CO: Fig. 3). The *E. pulchella* dominated control (CP) was positioned in Mt. Morrison block, compartment 16 (Fig. 3).

2.2.3 Forestry management of MM14

Two hundred and eighty-five hectares of the coupe were assessed by Forestry Commission personnel in 1974, who recorded a tree composition of 70% ash species (e.g. *E. obliqua*, *E. delegatensis*, *E. regnans*), 8% gum species (e.g. *E. globulus*, *E. viminalis*) and 22% peppermint species (e.g. *E. pulchella*, *E. amygdalina*) (Forestry Commission, Triabunna, unpublished). One hundred and ninety-three hectares of the assessed area were clearfelled for woodchips in winter 1981 after sawlog extraction. The remaining 92 hectares were designated as regrowth or protection forest.

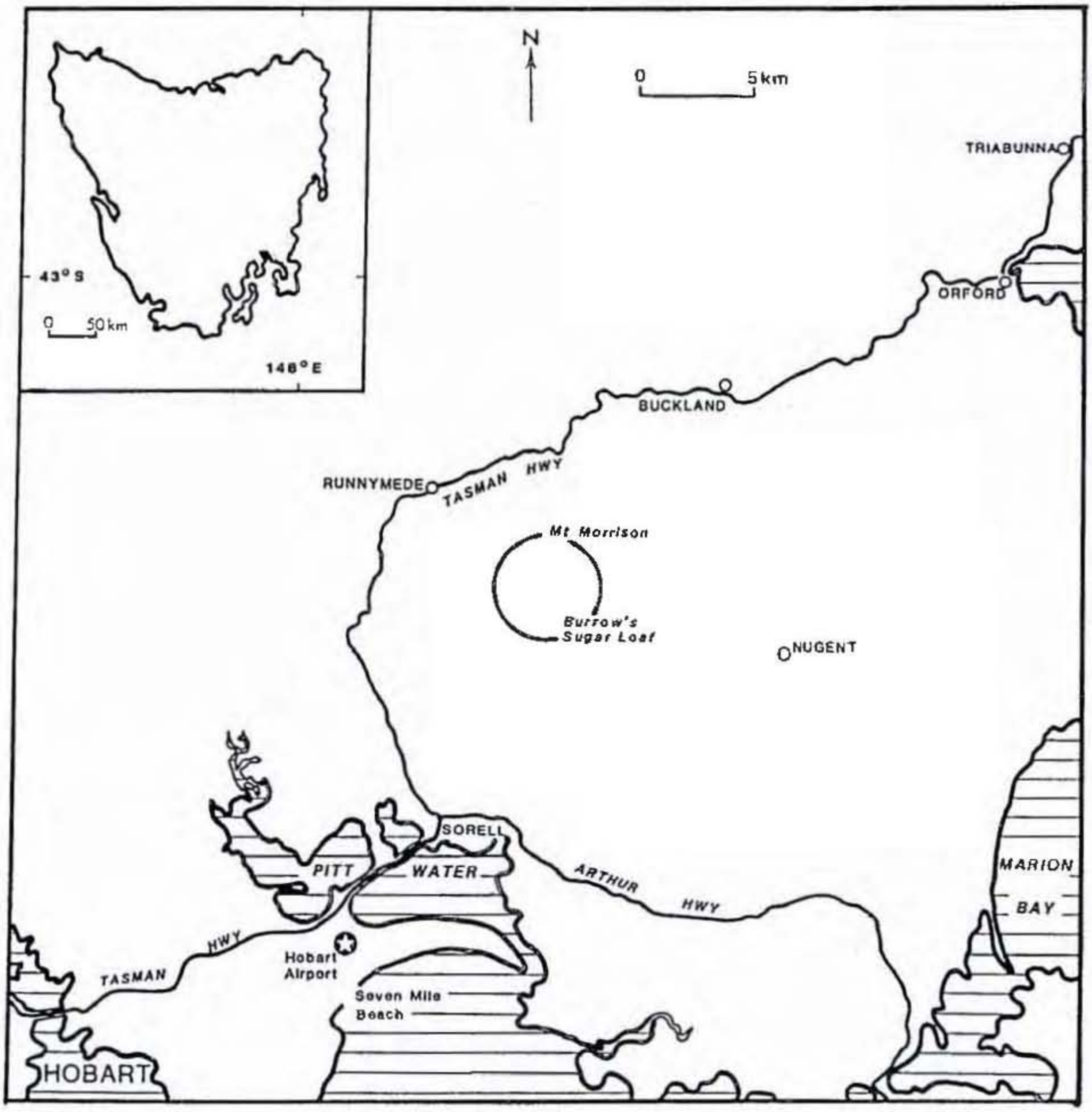
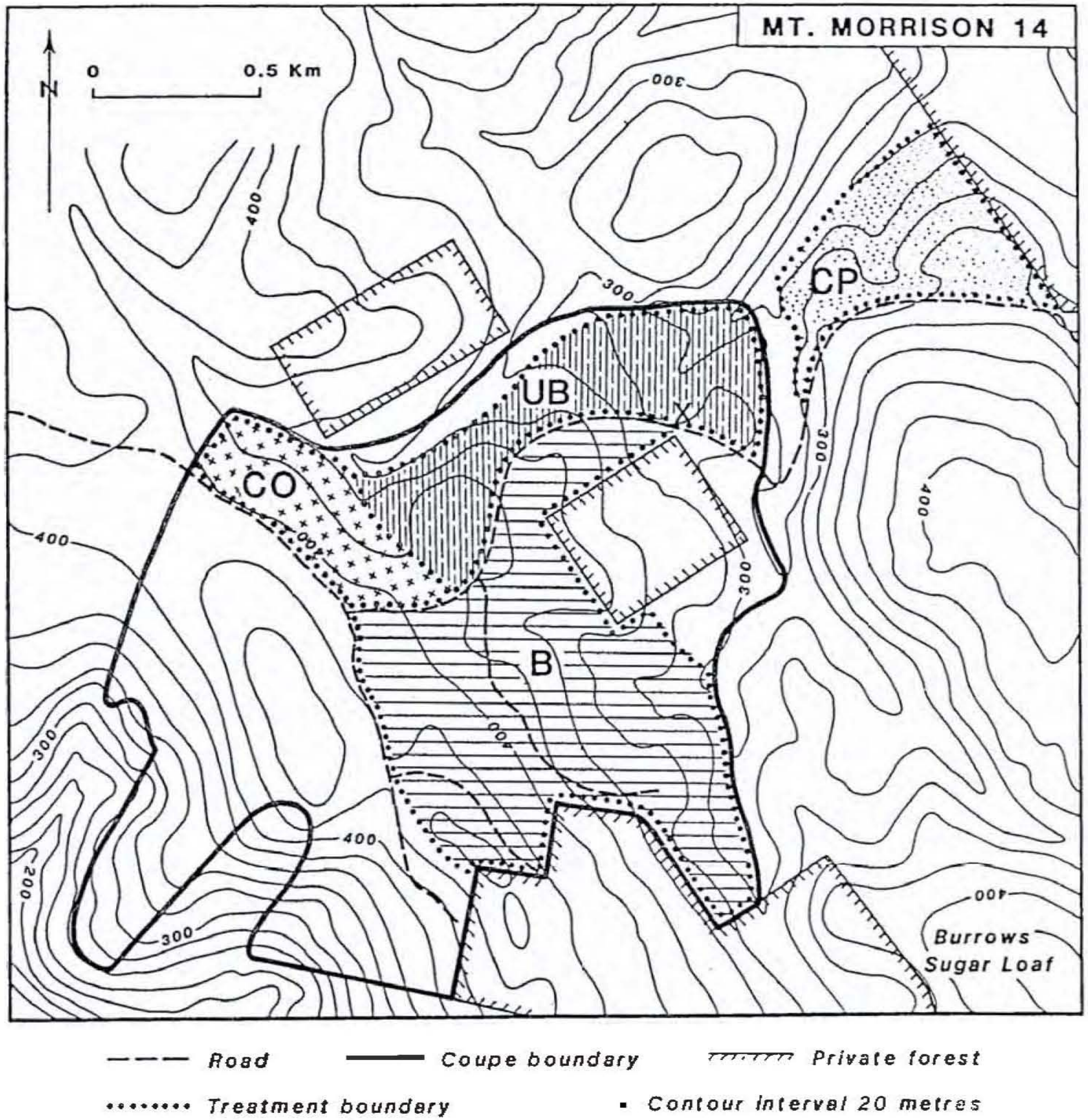


Fig. 2 : The location in southeastern Tasmania of the study area at MM14 (circled).

Fi 3 :
Contour map of the coupe MM14 depicting the burnt and unburnt treatments and control sites.

B treatment B (slash-burnt and sown);
UB treatment UB (slash left unburned, no artificial seeding);
CO = non-clearfelled forest dominated by Eucalyptus obliqua;
CP = non-clearfelled forest dominated by E. pulchella;
X = fixed point from which photographs of treatment B were taken.

(Note : CP lies in Mt. Morrison block, compartment 16.)



Standard management practice was adhered to for treatment B. Thus, clearfelling was followed by slash-burning in January 1982 and aerial sowing of seed (rate: 0.63 kg/ha; mix: 75% *E. obliqua*, 15% *E. amygdalina*, 10% *E. globulus*) in April 1982.

The trees on treatment UB were felled as for treatment B but the site was not burnt or aerially sown.

2.2.4 Climatic description

The Mt. Morrison region experiences a subhumid climate with most rainfall in autumn and winter (Gentilli, 1972). Nugent, the nearest rainfall recording station (Fig. 2), has a mean annual rainfall of 834mm (calculated for the period 1911-1982) compared to Hobart Airport (Fig. 2) which averages 553mm per year (period 1944-1982). Precipitation measured from two rain gauges at MM14 (altitude 390m) over approximately two years, indicated greater total rainfall than equivalent available figures for Nugent or Hobart Airport (Appendix 1). Rainfall was well below average in southeastern Tasmania in 1982.

The mean daily minimum and maximum temperatures (period 1944-1981) at the nearest climatic recording station, Hobart Airport, are 11.6^{o}C and 22.4^{o}C respectively for the warmest month, and 3.7^{o}C and 12.1^{o}C respectively for the coldest month. Applying approximate environmental lapse rates calculated for Mt. Wellington, near Hobart (M. Nunez, personal communication), the corresponding figures for MM14 are 7.7^{o}C and 19.5^{o}C for the warmest month, and 0.2^{o}C and 9.2^{o}C for the coldest month.

2.3 METHODS

2.3.1 Floristic survey

Approximately 25, 5m x 5m, quadrats were randomly located in each of the vegetation types described above, on both treatments B and UB, and in the control areas. The quadrats were surveyed for species presence-absence in November/December 1981 on the clearfelled treatments so that the relevant part of the site could be burnt as soon as possible, and in February 1982 in the case of the control areas.

The positions of the quadrats were chosen by selecting points using a stratified random sampling procedure. Maps of the treatments and controls at a scale of 20 chains to the inch (approximately 1 : 15790) were overlaid by a grid of 1.0cm x 1.0cm or 0.5cm x 0.5cm squares, depending on the area covered by each of the vegetation types in the particular treatment or control. Random number tables were used to obtain x, y co-ordinates for the location of each point within a particular square.

Random placings were located in the field by means of compass bearings and measured pacing, and were marked by flagging tape. Quadrats were aligned with one axis in the direction of slope with the random point always taken as the upslope left-hand corner. Some points were not used when located in the field due to their occurrence in a vegetation type to which they had not been assigned during the grid placements.

For relocation of quadrats on treatment B after the slash-burn, detailed reference notes were made of bearings from and measured distances to known markers, usually conspicuously situated metal stakes. In addition, each individual quadrat was marked by a cairn or metal stake at one or two of the corners. Reference diagrams were made of the quadrat number, corner(s) marked and the bearings of the two quadrat axes to enable both relocation and as near identical re-orientation of the quadrat as was possible after the slash-burn.

2.3.2 Permanent plot selection

Presence-absence data for all the quadrats on each treatment were analysed for percentage similarity using the method of Kirkpatrick (1982), such that percentage similarity equalled the number of species in common between a particular two quadrats, divided by the number of species in the quadrat with the smaller number of species, all multiplied by 100.

Initial problems in identification necessitated some grouping of species. Those combined were: *Agrostis* spp.; *Danthonia* spp.; *Deyeuxia* spp.; *Galium* spp.; *Juncus* spp.; *Luzula* spp.; *Olearia lirata* and *Olearia stellulata* (referred to as *Olearia* spp.); Orchidaceae spp. (except for *Acianthus caudatus*); *Pentapogon quadrifidus* and *Dichelachne sciurea* (referred to as *Pentapogon/ Dichelachne*); *Poa* spp. (except for *Poa annua*); *Senecio* spp.; *Stipa* spp..

Except where authorities are given, nomenclature of plant species follows Curtis (1963, 1967), Curtis and Morris (1975) for Dicotyledoneae, Curtis (1979) for Orchidaceae and Willis (1970) for Pteridophyta and Monocotyledoneae, excepting Tasmanian endemics which follow Curtis and Stones (1978).

Floristically similar permanent plots in each vegetation type were chosen first from treatments B and UB, and then similar quadrats were selected from the control sites, C. Two sets of permanent quadrats were chosen (referred to subsequently as Selection 1 and Selection 2) for each vegetation type giving a total of 12 plots. Selection criteria where possible were as follows: $\geqslant 70\%$ floristic similarity between the quadrats; the number of species in each 5m x 5m quadrat to differ by $\leqslant 7$.

2.3.3 The slash-burn

The regeneration burn took place on 11th January, 1982 in clear, calm conditions (Plate 1). Fire intensity was patchy, with some areas, particularly the drier sites, escaping fire altogether. Other parts, especially the creek habitats and type O communities experienced hot, intense fire (Plate 1).

2.3.4 Recording within the permanent plots

After the slash-burn, the chosen permanent quadrats were relocated. Some modification of selection was necessary once field conditions were assessed as not all the quadrats allocated to treatment B had been burnt.

Each 5m x 5m permanent plot was marked by metal stakes at the corners and subdivided into a grid of 25, 1m x 1m, sudquadrats. As the plots were to be intensively recorded over a 2 year period, minimum disturbance by the recorder was required. Therefore a central corridor 0.5m in width, was demarcated and omitted from recording on treatment B, thus enabling access to subquadrats without disturbance of their contents (see Fig. 4a). The width of 0.5m was replaced by 1m on plots located on treatment UB and in the control areas, due to obstruction by slash and undergrowth which made access difficult (Plate 3).

(1) Treatment B

Each 1m x 1m subquadrat was recorded in detail using a 20cm x 20cm frame as a field reference (Plate 1). One-to-ten scale maps were made of individual subplots (Fig. 4b), recording the cover of the descriptive features, rock, bare ground, wood, severely fire-baked soil and miscellaneous charred wood and plant material, as well as individual

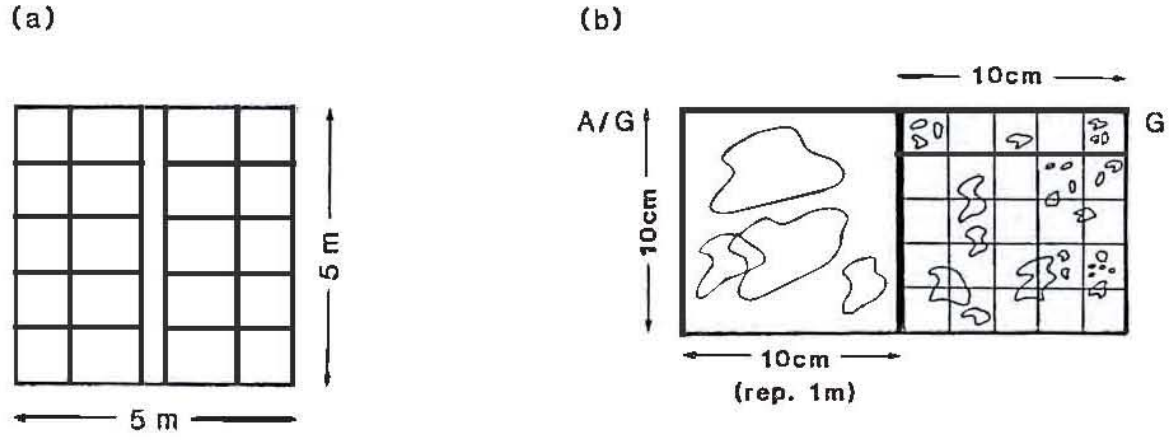


Fig. 4 : (a) Design of the 5m x 5m permanent plots showing the central corridor which was omitted from recording.

(b) Method for recording cover in each subquadrat. Each $1m^2$ subquadrat was mapped at a scale of 1 to 10. Where necessary recording was divided into 2 categories to aid clarity: A/G = above-ground; G = ground (see text).

Plate 1 :

(A) The slash-burn at MM14 on January 11th, 1982 viewed from the fixed point X (Fig. 3). The area covered by the photograph is in vegetation type O. The fire was confined to the area of the coupe that is shown and did not escape into the uncut forest pictured in the top left of the photograph. Burning of large areas (broadcast burning) produces the large smoke column depicted.

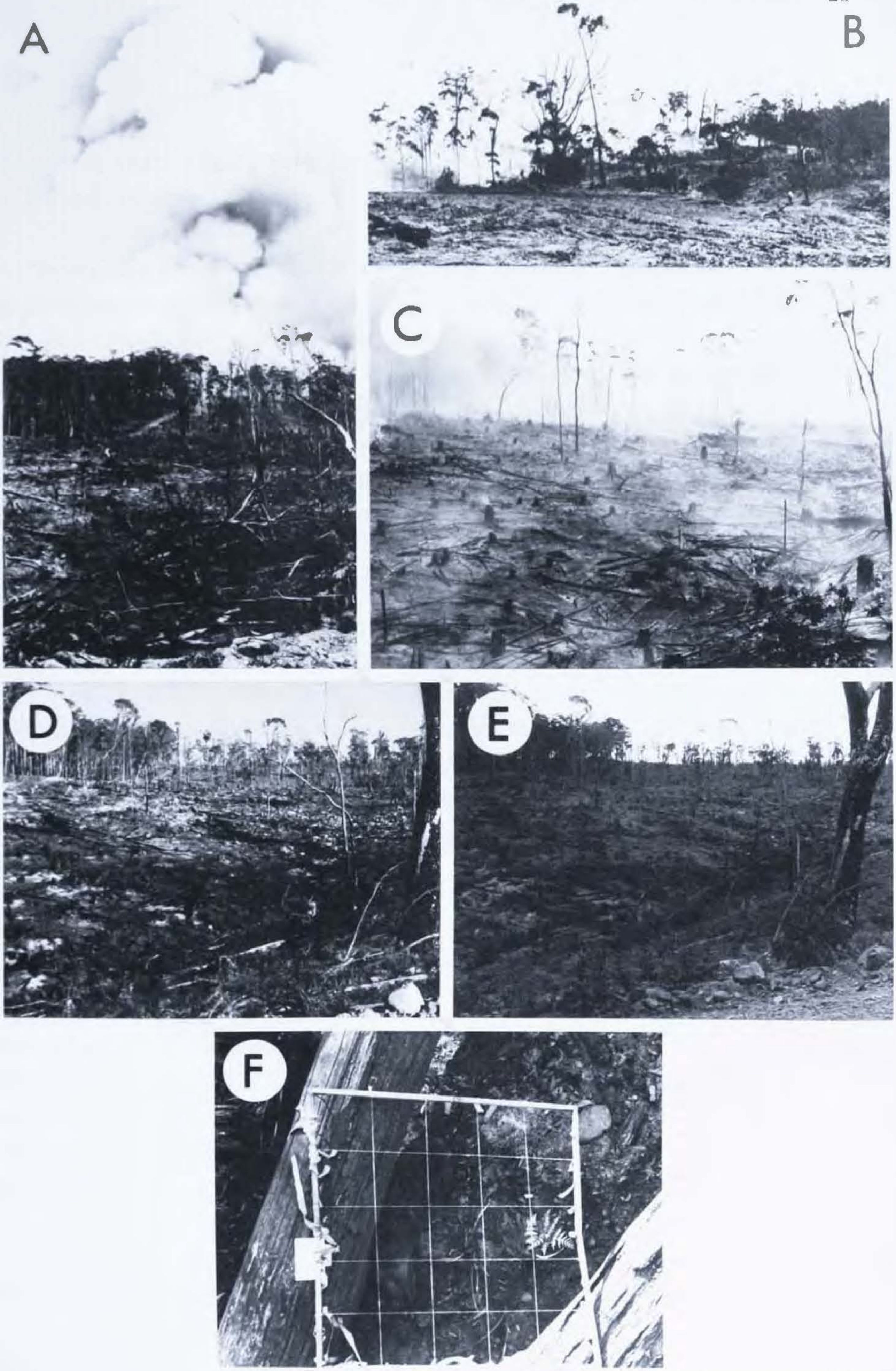
(B) The burning of treatment B at MM14 (left of picture). The unburnt area to the right of the picture is part of treatment UB. The trees shown are advanced natural eucalypt regeneration, which were destroyed by the fire on treatment B but remained undamaged on treatment UB. The large area in the foreground was used as a log landing during the logging operations and remained unvegetated for the entire period of study.

(C) Treatment B viewed from point X (Fig. 3), one day after the slash-burn. The majority of the advanced eucalypt regeneration has been destroyed, isolated trees have retained part of their canopy but will have sustained severe fire damage as a result of the slash-burn. The fine fuel has been removed by the fire (see Chapter 4) but a large amount of coarse fuel remains.

(D) Treatment B viewed from the fixed point X (Fig. 3), 17 months after the slash-burn (June 1983). Regrowth of understorey vegetation is particularly successful in the creek areas (centre and bottom left of photograph). The lighter areas are mainly mechanically disturbed ground which has not been revegetated (compare with (A)).

(E) Treatment B viewed from the point X (Fig. 3), 24 months after the slash-burn (January 1984). Cover of understorey species is more continuous than depicted in (D). Regrowth in the creek areas is dominated by Gahnia grandis. Mechanically disturbed sites still lack plant cover due to excessive compaction of the soil.

(F) The 20cm x 20cm frame used as a field reference for the compilation of the one-to-ten scale maps of each $1m^2$ subquadrat within the individual permanent plots. The subquadrat shown is in type O and pictured 2 months after the slash-burn. Pteridium esculentum is already established (centre right).


A
B
C
D
E
F

plants and their cover. Fire intensity was visually assessed according to the degree of soil baking.

To monitor the rapid post-fire species dynamics a geometric progression in mapping-times was chosen. Mapping was undertaken in February, March, May and September 1982, May 1983 and January 1984, that is 1, 2, 4, 8, 16 and 24 months after the slash-burn. The successive cover records were made on transparent sheets. Maps from previous time periods were used as underlays to provide maximum objectivity in identification and recording. The method provided a ready indication of whether an individual was still present, had disappeared, died, grown or reduced in size.

The approach also enabled back-checking of species, especially Gramineae which could not be identified in the early stages of recording. Examples of successive maps are given in Fig. 5 and the corresponding overlay transparencies in the sleeve (inside back cover). Notes were made throughout the course of mapping of any evidence of grazing or browsing (see Chapter 3). In addition, the maximum heights of each species present on each permanent plot were recorded in January 1984.

(2) Treatment UB

The recording methods used on treatment UB were closely similar to those employed on treatment B. Four one-metre poles were used to delineate the subquadrats which were often obscured by slash. Furthermore, to avoid unnecessary confusion, the cover of plant species and descriptive features were recorded in above-ground or ground-level categories on adjacent, but separate maps (Fig. 4b).

Recording on treatment UB was undertaken in May and September 1982, June 1983 and January 1984, that is 4, 8, 17 and 24 months after the

Fig. 5 :

Examples of the one to ten scale maps made of each of the 1m x 1m subquadrats within the 5m x 5m permanent plots. Cover of plant species and descriptive features were recorded at each time period for the individual subquadrats (see section 2.3.4). Note: (a) and (c) are incorporated into the text, (b) and (d) are overlay transparencies which are located in the sleeve (inside back cover). Cover of descriptive features such as rocks, logs etc. are only shown for February 1982.

(a) and (b) depict regrowth one month (February 1982) and 24 months (January 1984) after the slash-burn in four 1m x 1m subquadrats in one of the type O permanent plots on treatment B. The subquadrats were burnt by high and medium-low intensity fire.

(c) and (d) depict regrowth one month (February 1982) and 24 months (January 1984) after the slash-burn in four 1m x 1m subquadrats in one of the type P permanent plots on treatment B. The subquadrats were burnt by low-medium intensity fire.

A = Arthropodium milleflorum
Ac = Acacia sp.
Ad = Acacia dealbata
AG = Agrostis aemula
Ag = Agrostis parviflora
Ag2= Agrostis venusta
Am = Eucalyptus amygdalina
Anz= Acaena novae-zelandiae
Ast= Astroloma humifusum
B = Wahlenbergia spp.
Bo = Bossiaea prostrata
BP = Poa rodwayi
Car= Carex breviculmis
CH = Miscellaneous charred material
Ci = Cirsium vulgare
D = Diplarrena moraea
Da = Danthonia spp.
Di = Dianella tasmanica
Dy = Deyeuxia spp.
Ep = Epacris impressa
Epil=Epilobium sarmentaceum
Fe = Festuca asperula
Gal= Galium australe
GG = Gahnia grandis
GG(rem)=Remains of the basal shoots or flowers of Gahnia grandis
Gna= Gnaphalium collinum
Go = Goodenia lanata
GT = Haloragis tetragyna
Hs = Helichrysum scorpioides
Hy = Hypericum gramineum
Hyd= Hydrocotyle javanica
Hyp= Hypochaeris radicata
Liv= Liverwort
Lo = Lomandra longifolia
Log= Limbs or logs present after the slash-burn
Lom= Lomatia tinctoria
Ls = Leptospermum scoparium
Mic= Microlaena stipoides
Op = Opercularia varia
Os = Olearia spp.
P = Poa labillardieri
Pe = Pentapogon/Dichelachne
PL = Plantago varia
Pr = Pratia pedunculata
Pt = Pteridium esculentum
R = Rock
S = Severely fire-baked soil
(S)= Severely fire-baked soil underneath log
Sa = Schoenus apogon
Se = Senecio minimus
St = Stump
Sti= Stipa spp.
Stip=Stipa pubinodis
V = Viola hederacea

Blank areas denote bare ground

Fig. 5 (a)

FEB. 1982

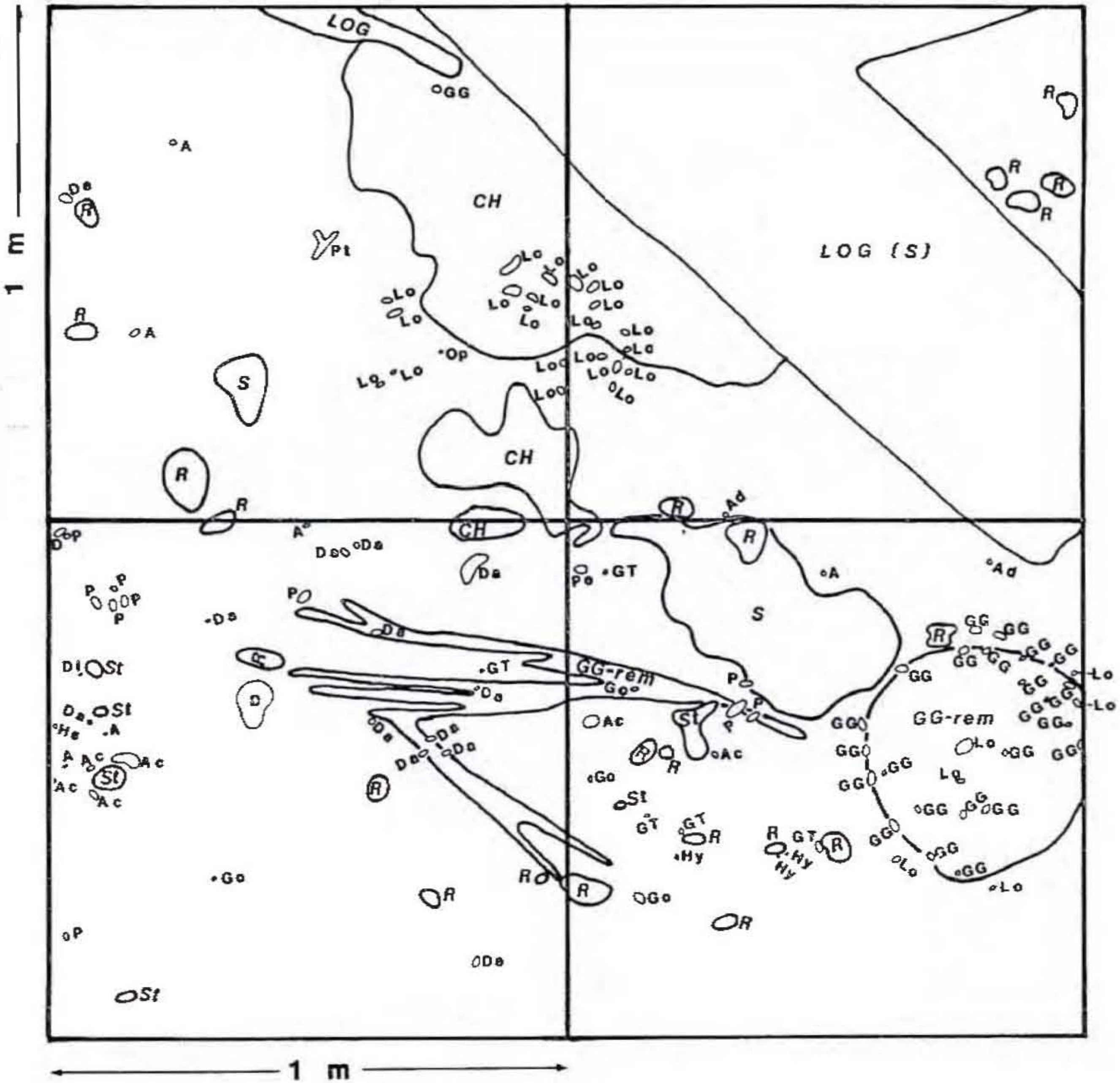


Fig. 5 (c)

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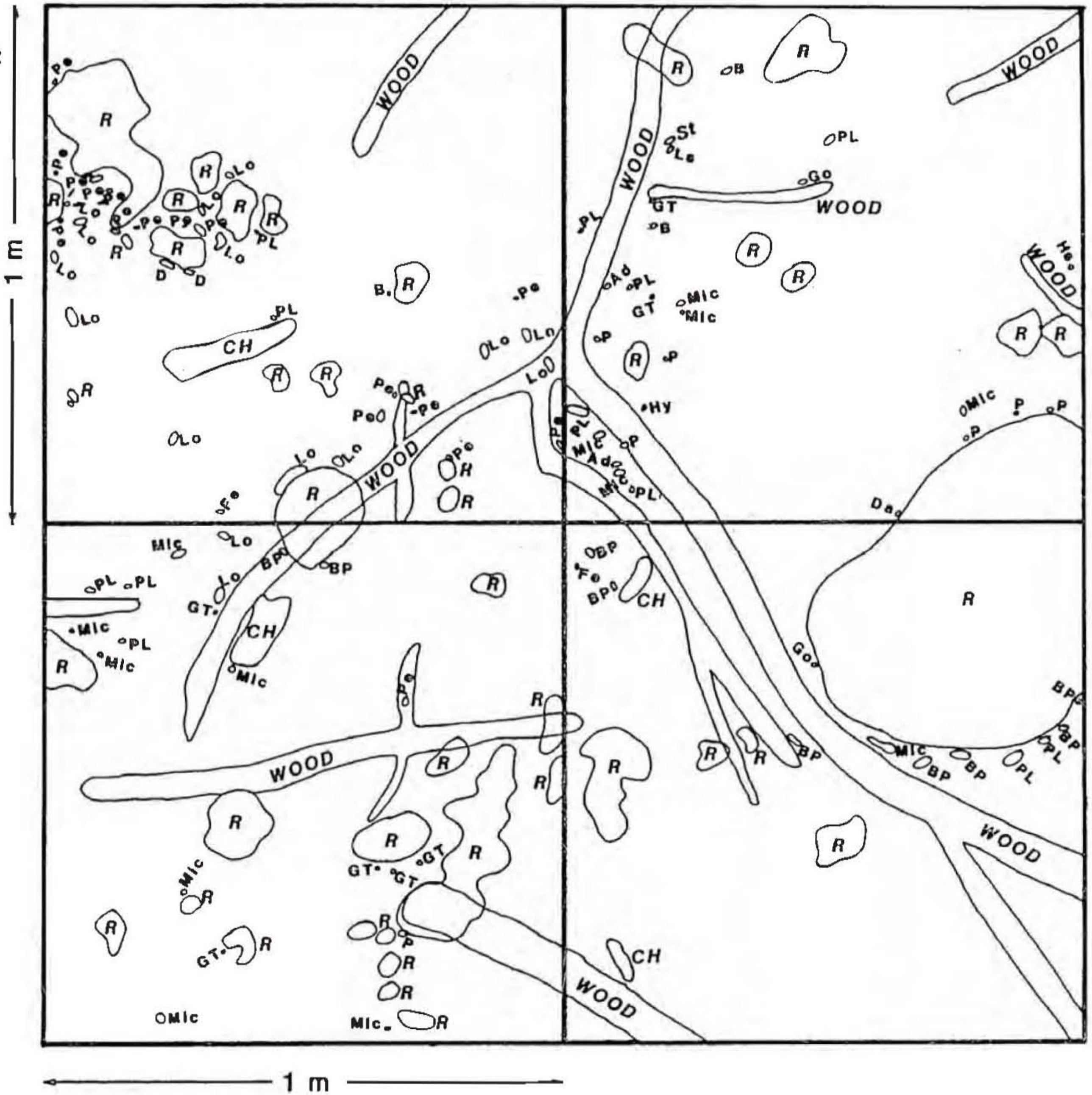


time of the slash-burn on treatment B, which corresponded approximately to 8, 12, 21 and 28 months after clearfelling.

The maximum heights of species occurring on the plots, were recorded in January 1984.

(3) The control areas

The sampling details were identical to those used on treatment UB.

However, a wildfire in August 1984 burnt one macro-permanent plot in the type P control area (CP: Fig. 3). Consequently, the 3-way quadrat selection within type P between the control and treatments B and UB was modified. The burnt permanent plot in the type P control area was relocated on an adjacent unburnt site of the same slope, aspect and orientation. The species composition of this replicate plot was recorded, and the percentage similarities with the original permanent plot, and the previously selected similar plots on treatments B and UB, were calculated. The calculated similarities validated the assumption that the relocated control quadrat was floristically similar to the original which had been burnt. Consequently, records were made for the relocated permanent plot and the similar plot on treatment UB, in September 1982, June 1983 and January 1984, that is 8, 17 and 24 months after the time of the slash-burn on treatment B.

All the macro-permanent plots were monitored by fixed point photography throughout the study period (Plates 2, 3). An additional fixed point was also established at point X overlooking treatment B (Fig. 3) and monitored concurrently (Plate 1).

During the detailed vegetation mapping the species groupings were as follows: Chiloglottis spp.; Corybas spp.; Danthonia caespitosa and Danthonia penicillata (referred to as Danthonia spp.); Deyeuxia *monticola* and *Deyeuxia quadriseta* (referred to as *Deyeuxia* spp.); *Olearia lirata* and *Olearia stellulata* (referred to as *Olearia* spp.); *Pentapogon quadrifidus* and *Dichelachne sciurea* (referred to as *Pentapogon/Dichelachne*); *Stipa* spp. (except for *Stipa pubinodis*); *Wahlenbergia* spp..

2.3.5 Fire-free period

To establish the approximate time since the last fire on treatment UB and the control sites, three specimens of *Acacia dealbata* were sampled in the vicinity of each permanent plot in each vegetation type in October, 1983. The basal diameter of each specimen was recorded using vernier callipers and the number of growth rings were counted (Table 2). The basal area was then calculated for each specimen. The number of growth rings and basal area for all the specimens were tested for significant difference ($p = 0.05$) within and between the vegetation types using the Mann-Whitney U Test. The basal area differed between types P and O, but not between treatment UB and the control within the same vegetation type. The individuals which occurred in type O displayed greater basal area than those in type P ($p = 0.002$). However, there was no significant difference at $p = 0.05$ in number of growth rings within or between vegetation types.

From these results it seems likely that the specimens of *A. dealbata* sampled from treatment UB and the control areas in type P and type O, regenerated following the same fire. The extensive wildfires which occurred in 1967 throughout southern Tasmania (Chambers and Brettingham-Moore, 1967) are known to have spread to the Mt. Morrison area (P.J. Bennett, personal communication 1981). It is probable that these were the last intense fires to occur at MM14.

In a study of native mammals, their habitats and nesting requirements, near the type P control plots in February 1982, a selection of adult eucalypts were found to have sap rings aged at 4, 6,

Veg. type	Treatment/ control	Mean no. of growth rings	Range	Mean basal area (cm^2)	Range
P	UB	10.3	9 - 11	7.6	4.5 - 10.2
	C	10.2	9 - 11	6.3	4.5 - 8.6
O	UB	10.2	9 - 11	11.9	6.4 - 20.0
	C	10.7	10 - 12	10.4	5.5 - 14.9

TABLE 2 : The mean and range of the number of growth rings and basal area (cm^2) of six individuals of *Acacia dealbata* measured in each vegetation type on treatment UB and in the control areas.

8, 10 and 14 years (D. Peters, personal communication). The sap rings may have resulted from repeated low intensity fires, which were used by local graziers to stimulate fresh plant growth for domestic stock, especially in the type P forests. It is likely that intermittent sheep grazing continued in the Mt. Morrison area until the late 1970's.

2.3.6 Eucalypt regeneration

The density, height, basal diameter and species composition of eucalypt regeneration on treatments B and UB were assessed in January 1984 using the point-centred quarter method (Mueller-Dombois and Ellenberg, 1974) at each of the random points used in the floristic survey (Fig. 12). Notes and observations also were made regarding the nature of the eucalypt regeneration, that is whether the regrowth was from seed, lignotuber, coppice, basal resprouting from a damaged sapling, or was present as natural advanced growth. The nature of regeneration was tested for significant difference at $p = 0.05$ between vegetation types P and O, and between treatments B and UB using the chi-squared statisic.

In order to compare the results obtained at MM14 with older ages of regeneration, the point-centred quarter method was also used to establish density, height and species composition of eucalypts in two other East Coast coupes on dolerite, with varying ages of regrowth resulting from slash-burning. Tooms block, compartment 2 (hereafter referred to as TO2) and Mt. Morrison block, compartment 20 (hereafter referred to as MM20) (Fig. 6) both encompassed similar vegetation types to those present at MM14. The coupes had been clearfelled, slash-burnt and aerially sown with seed in 1974 and 1978 respectively.

Sections of the coupes MM20 and TO2 were chosen for study. The portions selected were of similar altitude and aspect to the main experimental area at MM14 (Figs. 7,8). Twenty-five random points were chosen in the Eucalyptus obliqua and E. pulchella dominated communities (Figs. 7,8), and sampled during the summer of 1982/83. Random placements were selected using maps (approximately 1 : 15790) of each vegetation

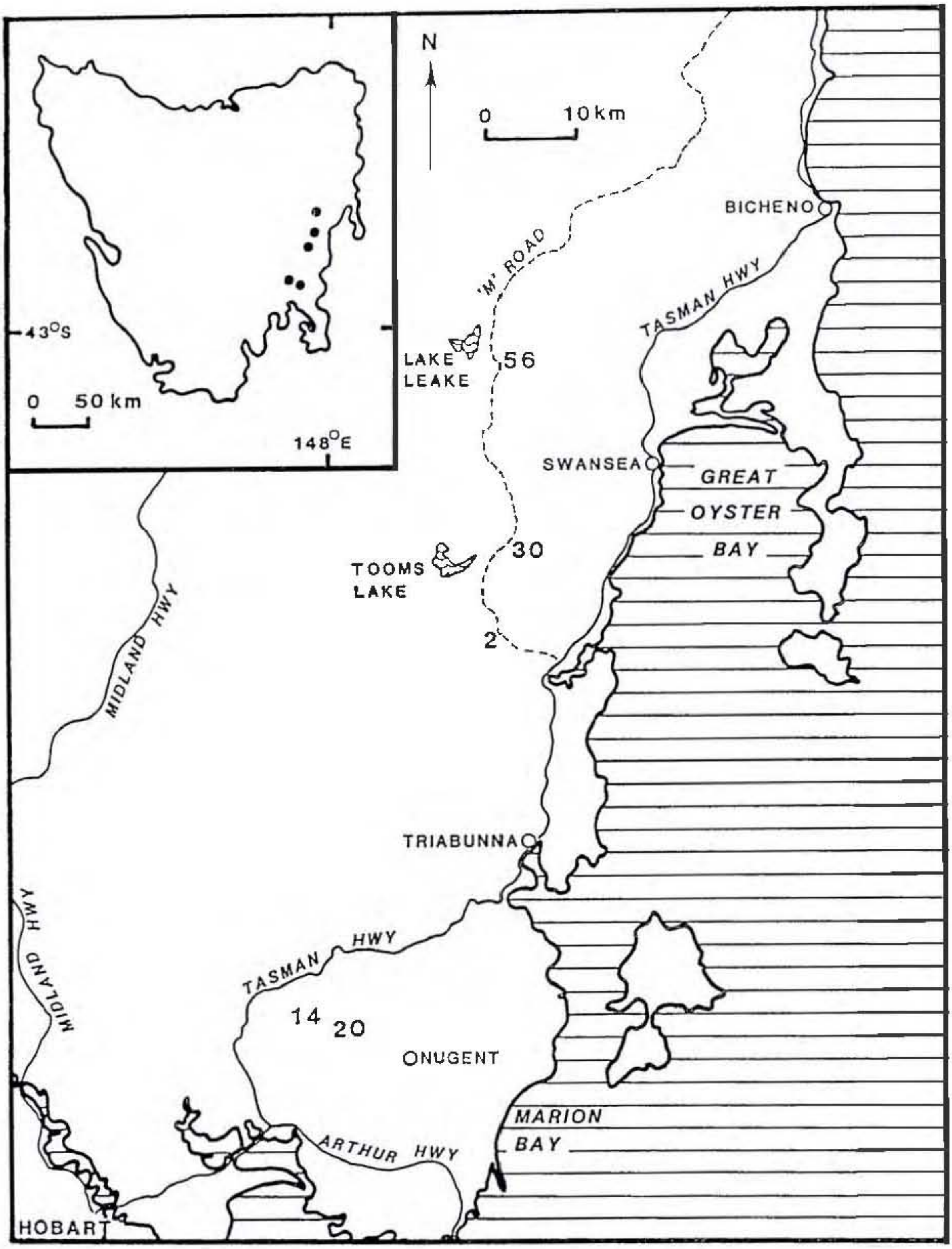


Fig. 6 : The location of the East Coast coupes sampled.

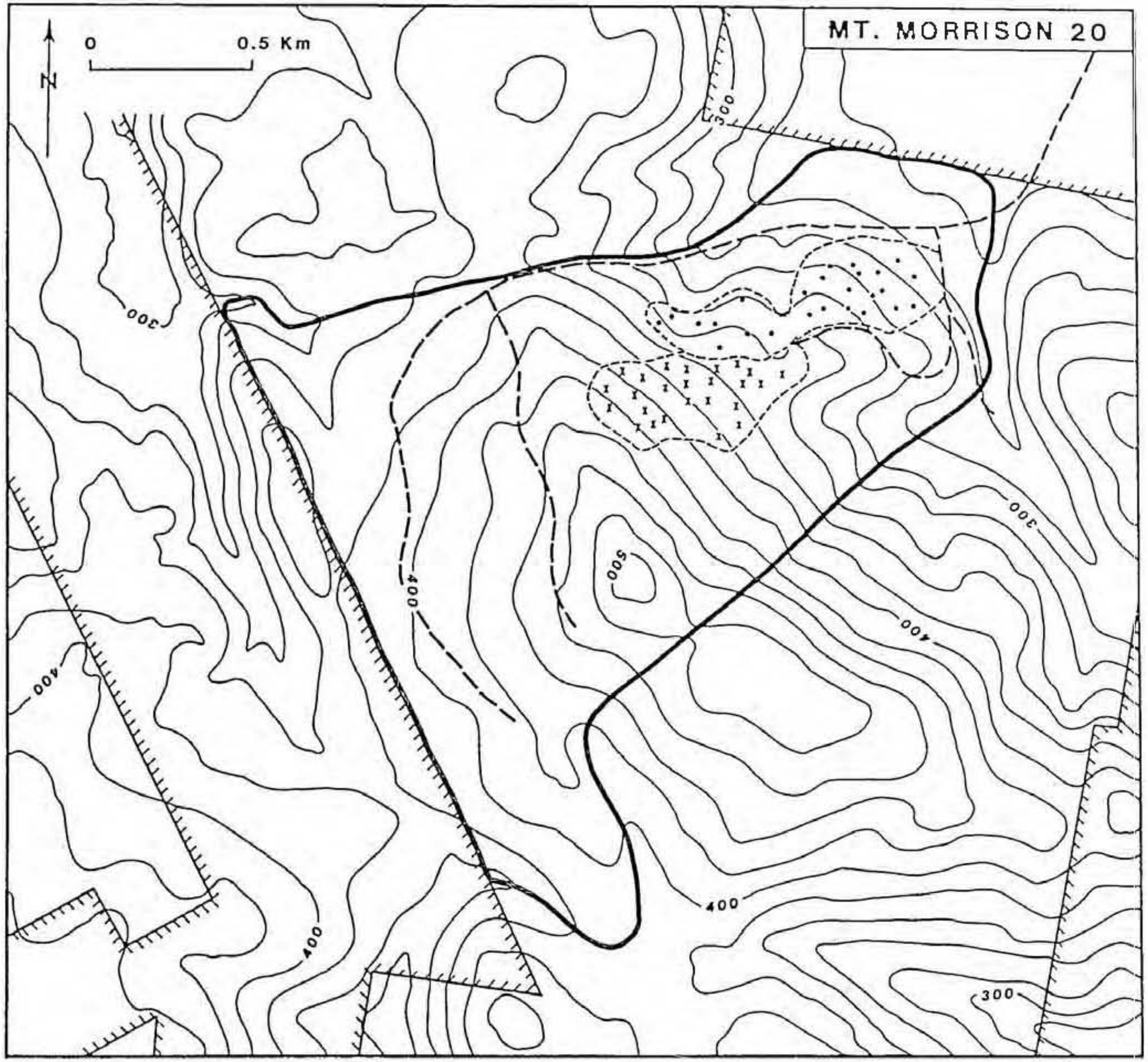
14 = MM14; 20 = Mt. Morrison block, compartment 20 (MM20); 2 = Tooms block, compartment 2 (TO2); 30 = Tooms block, compartment 30 (TO30); 56 = Tooms block, compartment 56 (TO56).

Fig. 7 :

Contour map of the coupe MM20 showing the location of the random points used as the sampling sites in the eucalypt studies (section 2.3.6) and the fuel studies (Chapter 4).

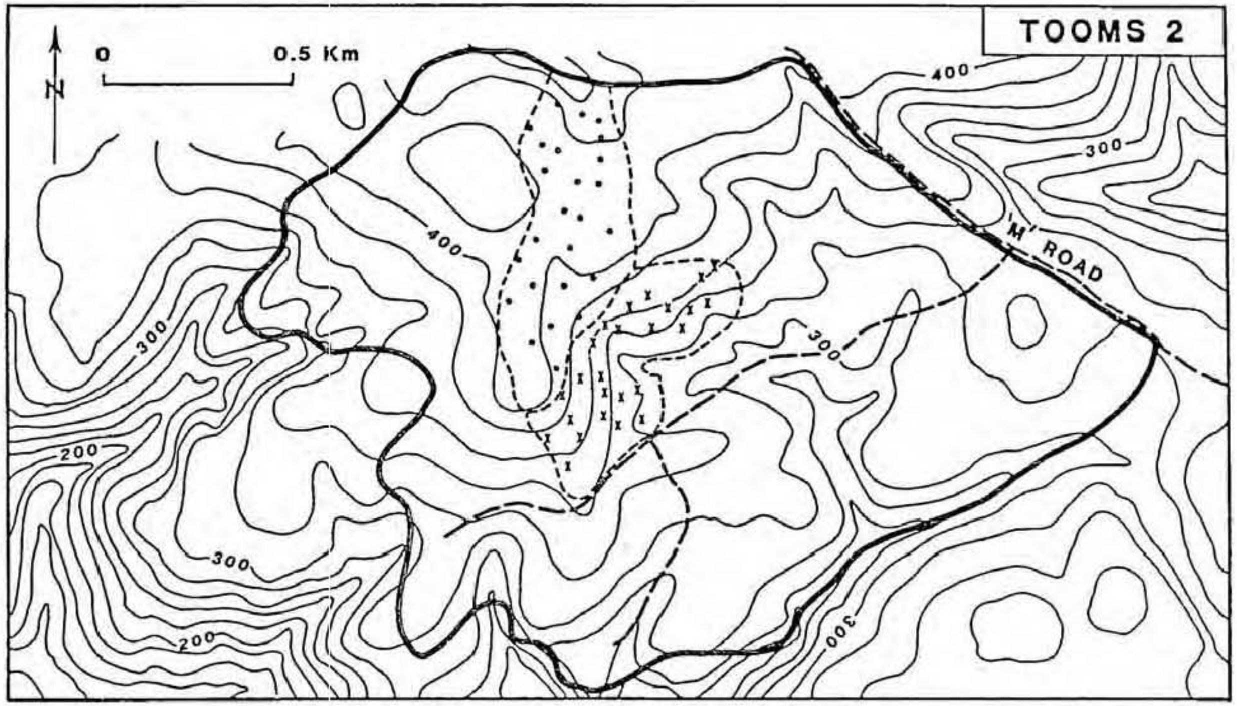
● = plots located in type P;

X = plots located in type O.



Road   Coupe boundary   Private forest

Contour interval 20 metres



— — — *Road* ——— *Coupe boundary* *Contour interval 20 metres*

Fig. 8 : Contour map of the coupe TO2 showing the location of the random points used as the sampling sites in the eucalypt studies (section 2.3.6) and the fuel studies (Chapter 4).

● = plots located in type P; X = plots located in type O.

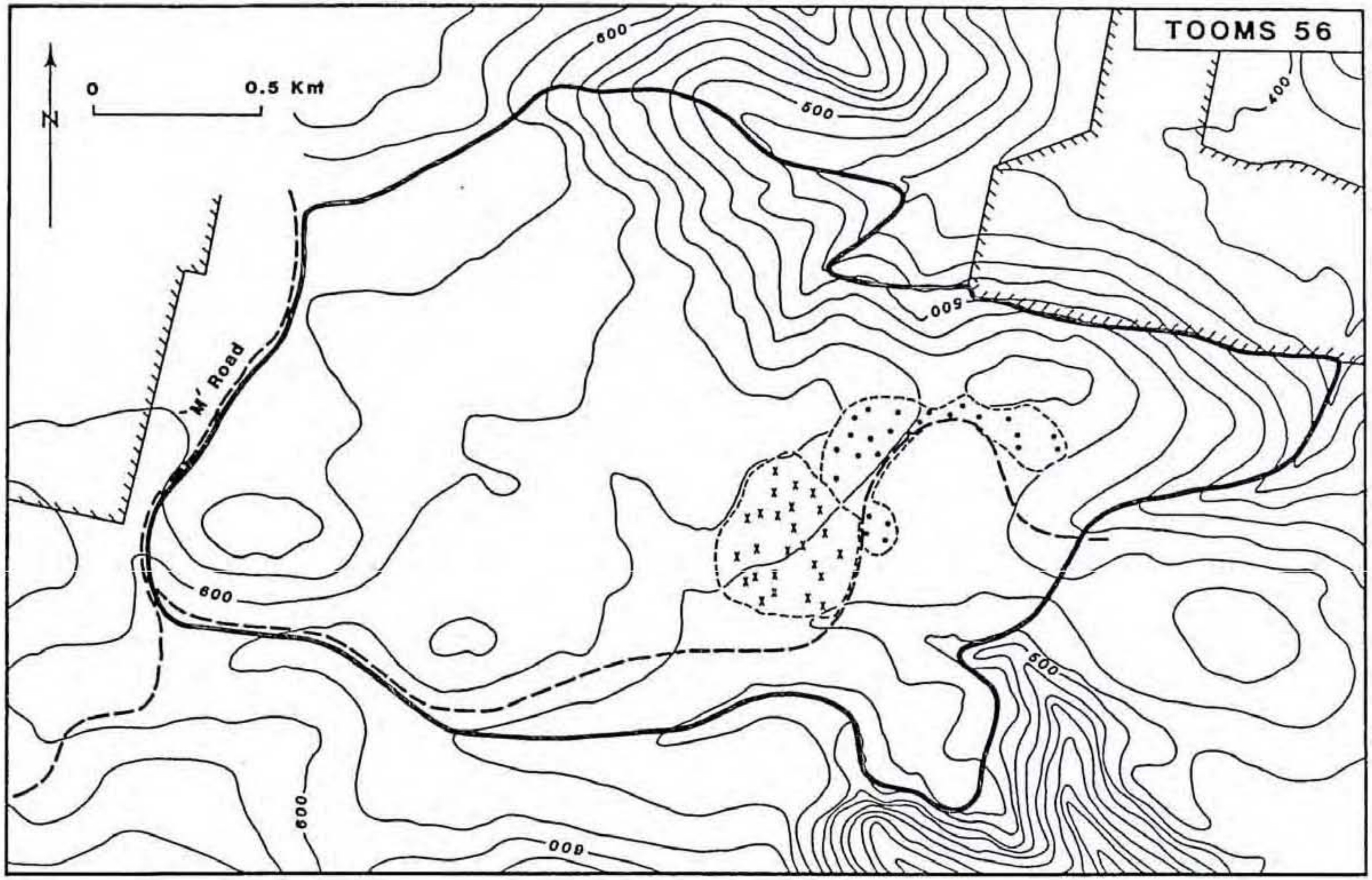
type overlaid by a grid of 0.5cm x 0.5cm, and located in the field, in a similar manner to the methods described for MM14 (section 2.3.1).

Suitable burnt and unburnt comparisons in older regeneration than that present at MM14, were not available for vegetation types P and O, but ideal examples occurred in higher altitude forests on dolerite which were dominated by E. delegatensis and E. obliqua (hereafter referred to as type D/O). Consequently, two additional coupes, Tooms block, compartments 30 and 56 (subsequently referred to as TO30 and TO56) with regeneration dating from 1975 and 1976 respectively, were added to the study (Fig. 6). Twenty-five random sampling points were located in each coupe in each of the burnt and unburnt sections (Figs. 9,10). The burnt and unburnt portions of the coupe chosen for study were of similar altitude, topography and aspect. Random points were selected using maps of the burnt and unburnt sites and located in the field, in a similar manner to the methods used for the coupes MM14, MM20 and TO2.

The basal area calculated from the mean basal diameter, density and height of the eucalypts in each vegetation type and age of regeneration were tested for significant difference ($p = 0.05$) using the Kolmogorov-Smirnov test. In addition, to give an indication of coupe variation, the eucalypt species composition in each of the regrowth ages and vegetation types sampled, was expressed in terms of the absolute frequency of each species recorded, where;

$$\text{absolute frequency} = \frac{\text{number of random points at which the particular species was recorded}}{\text{total number of random points sampled}} \times 100$$

(after Mueller-Dombois and Ellenberg, 1974). The hypothesis was proposed that the eucalypt species composition present on treatment B, MM14 in both vegetation types P and O would not be statistically different to the composition of species present in the seed mix that was sown onto the coupe (section 2.2.3). The hypothesis was tested using the chi-squared statistic.



Road Coupe boundary Private forest Contour interval 20 metres

Fig. 9 : Contour map of the coupe TO56 showing the location of the random points used as the sampling sites in the eucalypt studies (section 2.3.6) and the fuel studies (Chapter 4). ● = plots located on the slash-burnt site; X = plots located on the unburnt site.

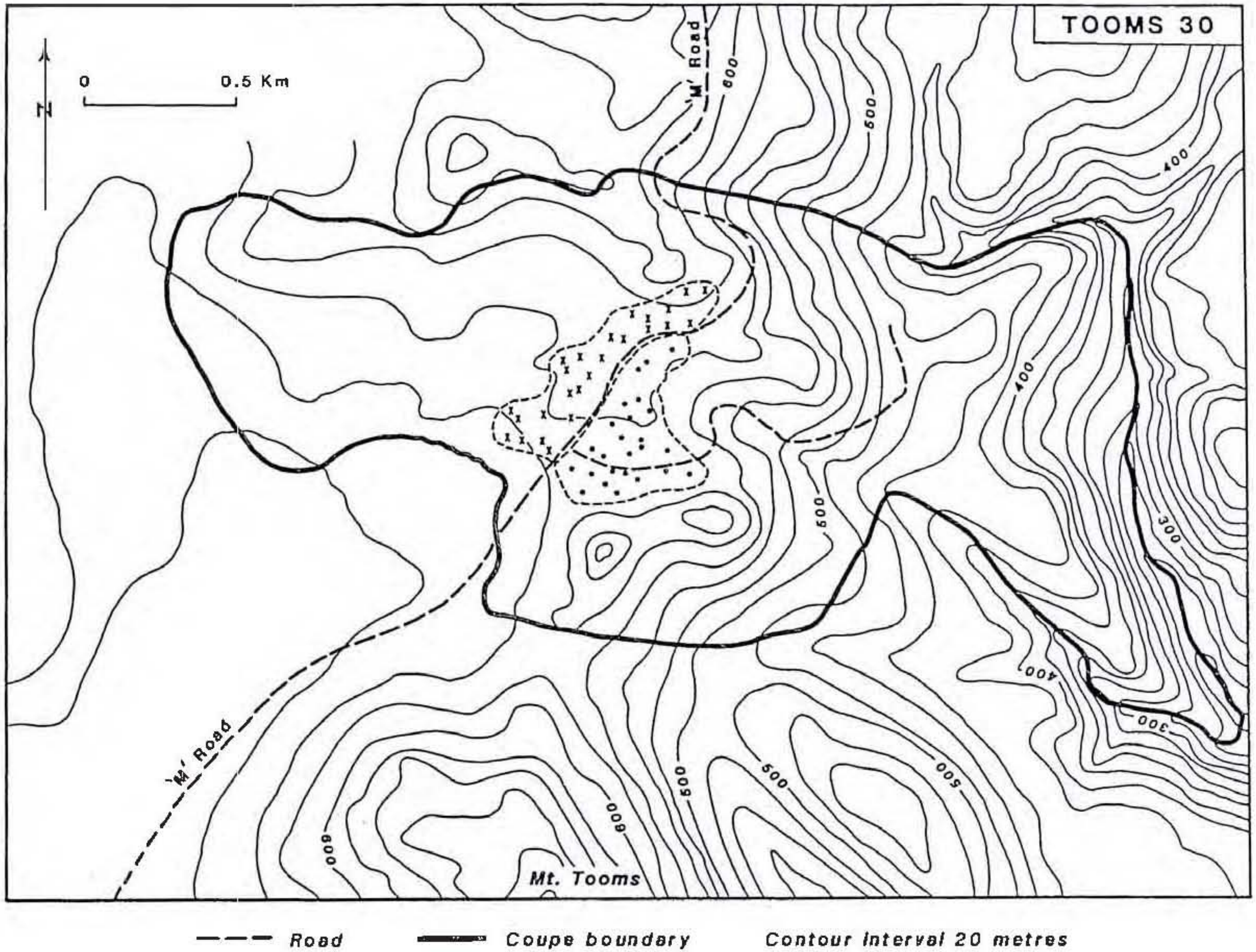


Fig. 10 : Contour map of the coupe TO30 showing the location of the random points used as the sampling sites in the eucalypt studies (section 2.3.6) and the fuel studies (Chapter 4).
● = plots located on the slash-burnt site; X = plots located on the unburnt site.

2.4 DATA EXTRACTION AND ANALYSIS

2.4.1 Floristic survey

Presence-absence data from the 153, 5m x 5m, quadrats sampled at MM14 were classified using the polythetic, divisive method employed in the program TWINSPAN (Hill, 1979a), and ordinated using detrended correspondence analysis (Hill and Gauch, 1980) operated by the program DECORANA (Hill, 1979b).

2.4.2 Permanent plots

Cover data from the maps of each subquadrat at each time period were obtained by assessing the area of individual species and descriptive features by eye, using an overlay grid of 0.5cm x 0.5cm as a template. Areas of large individuals and descriptive features were obtained by digitisation employing the computer program BIOQUANT (W.L. Weller, unpublished).

The cover values of individual species and descriptive features were summed within each subquadrat at each time period, and converted to percentage cover with values calculated to the nearest 0.01%. For treatment B, sections of the 0.25m strip on either side of the corridor (Fig. 4) were considered part of the adjacent $1m^2$ subquadrat and the percentage cover values were calculated for the $1.25m^2$ area.

All the percentage cover values obtained for the subquadrats were transferred onto computer files and manipulated using the computer package ECOPACK (Minchin, 1984). Ordered tables were produced showing the occurrence of individual species and their percentage cover through time on each of the subquadrats.

The primary hypothesis to be tested was that clearfelling plus slash-burning resulted in a greater ecological impact in dry eucalypt forests than clearfelling alone (see Chapter 1). Consequently, the mean percentage cover of individual species and descriptive features in each vegetation type, treatment and control, was obtained by amalgamating the data from the 2 macro-quadrats selected in each instance (section 2.3.2). The percentage cover results for each subquadrat were summed, averaged for the number of subquadrats within the 2 macro-quadrats, and the resulting mean values graphed against time. Thus, any discernible ecological trends were more likely to be the result of the disturbance rather than due to local environmental variation, differing fire intensity, or grazing effects. The effects of these local factors were tested separately by considering the permanent quadrats in detail.

The density and demographic change of selected species were monitored in detail on the treatment B macro-quadrats. Species where individuals were difficult or impossible to differentiate were excluded, for example, the rhizomatous regrowth of Pteridium esculentum, and the vegetative regrowth of various graminoids and shrubs. Some individuals of particular species coalesced through time making their consistent differentiation difficult. These species were therefore omitted, for example Bossiaea prostrata and Viola hederacea. Gnaphalium collinum was excluded in type P only. Records were made at each successive time period for each subquadrat. The number of new individuals and the number of individuals that had disappeared since the last mapping period, together with the density of individuals, were recorded. Figures for the establishment, disappearance, and density of each species in the subquadrats were summed and averaged to obtain mean values for each vegetation type and then expressed as number per $100m^2$.

Two species diversity indices were calculated for the macro-quadrats in each vegetation type, treatment and control, using;

(a) the reciprocal of Simpson's Index (Hill, 1973),

$$N_2 = ((\sum x)^2) / \sum (x^2),$$

where x = percentage cover of each species,

(b) the Shannon-Weaver index (Shannon and Weaver, 1949),

$$H' = - \sum_{i=1}^{n} p_i \ln p_i,$$

where p_i = the proportion of the total cover provided by the ith species and n = the number of species present on the plots at the specific recording times.

N_2 is a measure of the degree of species polydominance (Hill, 1973) with the maximum obtainable value being n, when all species have identical cover. When only one species has any appreciable cover, N_2 approximates to one.

In contrast, H' is most sensitive to changes in the rarest species (Peet, 1974) rather than to changes in importance of the most abundant species as in the case of N_2. N_2 is considered a more meaningful ecological measure of diversity than H' (Hill, 1973; Peet, 1974). However, H' has been more widely used in the literature; hence its inclusion in the present study for comparison with other published results.

Species richness (that is the number of species present) was also obtained for the macro-quadrats in each vegetation type, treatment and control for each of the recording times.

2.5 RESULTS

2.5.1 Floristic survey

Table 3 summarises the species and quadrat groups resulting from division to level 3 using the classification program TWINSPAN (Hill,

TABLE 3: Percentage frequency of selected species in eight quadrat groups resulting from division to level 3 using the classification program TWINSPAN (Hill 1979a). Vertical/horizontal lines link species groups/quadrat groups delineated at each classificatory level. Cl = climber; F = fern; G = grass; Gr = graminoid; H = herb; O = orchid; S = shrub; T = tree.

Life-form	Species	Quadrat group 1	2	3	4	5	6	7	8	Species group
S	Hibbertia riparia	6	8	15	16	5	0	0	0	
S	Lissanthe strigosa	69	62	85	26	0	5	15	0	
S	Bossiaea prostrata	100	92	93	42	14	0	8	0	
T	Eucalyptus pulchella	38	38	49	5	0	0	8	1	
H	Hypochaeris radicata	13	15	15	5	5	0	0	0	
S	Pimelea humilis	88	69	56	11	9	10	0	0	
H	Plantago varia	50	77	41	11	0	0	0	0	
S	Acrotriche serrulata	50	8	17	21	9	0	0	0	
H	Leptorhynchos squamatus	13	46	12	0	0	5	0	0	
G	Tetrarrhena distichophylla	6	31	8	11	0	0	8	0	1
S	Boronia nana	25	8	0	0	0	0	0	0	
Gr	Carex breviculmis	75	92	24	5	9	5	0	0	
S	Hovea heterophylla	63	46	0	5	0	0	0	0	
Gr	Lepidosperma lineare var. inops	63	8	2	5	0	0	0	0	
G	Themeda australis	94	54	8	11	0	0	0	0	
S	Acacia stricta	81	77	49	42	36	35	8	0	
H	Craspedia glauca	44	38	39	26	14	5	0	0	
S	Marianthus procumbens	25	0	5	0	0	5	0	0	
S	Pultenaea gunnii	0	0	20	5	0	0	8	0	
S	Callistemon pallidus	0	8	27	5	0	0	31	0	
S	Acacia genistifolia	0	0	7	16	5	0	0	0	
S	Daviesia ulicifolia	6	0	17	32	5	5	0	0	
Gr	Bulbine bulbosa	6	15	20	26	5	0	31	0	2
T	Eucalyptus amygdalina	0	23	24	26	5	0	8	0	
H	Brachycome scapiformis	44	31	49	37	18	0	15	22	
Gr	Dianella revoluta	13	0	22	11	9	0	8	0	
T	Eucalyptus viminalis	25	0	5	26	9	0	8	0	
S	Olearia erubescens	31	46	27	37	18	5	8	0	
G	Stipa spp.	100	100	41	32	36	35	23	0	
Gr	Anguillaria uniflora	0	8	2	11	0	0	15	0	
H	Oxalis corniculata	38	69	37	32	9	5	62	56	3
H	Drosera auriculata	13	15	78	68	45	0	62	0	
H	Sonchus asper	0	0	93	0	5	5	0	0	
G	Agrostis spp.	63	62	41	53	18	25	31	56	
G	Deyeuxia spp.	75	62	71	68	55	45	62	44	
H	Hypericum gramineum	88	100	95	79	68	35	85	89	
G	Microlaena stipoides	44	77	63	63	41	25	62	44	
Gr	Schoenus apogon	63	92	71	58	32	20	69	22	
Gr	Arthropodium milleflorum	25	62	76	74	41	40	54	0	
G	Pentapogon/Dichelachne	63	77	80	74	59	20	46	11	
H	Stylidium graminifolium	31	38	29	53	36	15	8	0	
S	Astroloma humifusum	94	77	63	68	64	45	23	11	
H	Haloragis tetragyna	100	100	95	100	82	60	62	33	
H	Goodenia lanata	94	77	76	63	50	55	38	0	4
Gr	Lomandra longifolia	94	100	83	79	82	70	62	11	
S	Acacia dealbata	81	62	80	79	82	70	62	78	
G	Danthonia spp.	75	92	83	84	91	90	92	67	
S	Epacris impressa	81	38	73	84	86	90	69	33	
S	Leptospermum scoparium	88	54	78	79	64	95	85	11	
G	Poa spp.	100	100	88	100	95	95	92	78	
H	Pratia pedunculata	0	38	17	5	9	10	15	33	
H	Viola hederacea	81	92	98	89	68	85	92	100	
H	Helichrysum scorpioides	44	85	88	89	86	75	62	22	
H	Lagenophora stipitata	38	92	88	89	86	85	54	56	
H	Wahlenbergia spp.	56	69	98	100	91	95	85	78	
H	Cirsium vulgare	6	31	27	42	32	30	46	8	
G	Festuca asperula	0	8	66	89	68	20	62	67	
S	Leucopogon collinus	6	0	7	16	0	20	8	0	
O	Orchidaceae spp.	19	31	51	53	27	35	46	67	
H	Senecio spp.	6	8	12	11	32	0	0	0	
F	Asplenium flabellifolium	0	0	32	0	0	25	46	33	
Gr	Luzula spp.	0	0	5	5	5	0	0	22	
H	Helichrysum dealbatum	0	0	24	11	5	25	54	11	
Gr	Lepidosperma laterale	31	23	39	21	23	45	69	56	5
H	Opercularia varia	44	0	32	21	45	45	15	11	
H	Gnaphalium collinum	44	77	41	26	55	55	77	44	
H	Poranthera microphylla	31	62	8	58	41	15	62	67	
T	Banksia marginata	6	0	2	16	9	10	0	0	
S	Lomatia tinctoria	50	46	54	89	95	90	46	44	6
S	Tetratheca glandulosa	0	0	10	26	36	15	0	0	
Gr	Diplarrena moraea	75	46	32	79	86	100	23	22	
S	Pultenaea juniperina	19	0	46	74	82	95	46	89	
H	Acaena novae-zelandiae	0	23	15	5	36	30	62	78	
H	Galium spp.	6	23	22	5	50	40	62	89	
H	Hydrocotyle javanica	0	31	20	26	45	20	54	89	
Gr	Gahnia grandis	0	0	29	5	27	100	69	67	
S	Cyathodes glauca	0	0	7	26	45	70	8	67	7
Gr	Dianella tasmanica	13	0	2	16	50	30	23	22	
T	Eucalyptus obliqua	6	0	24	42	82	90	62	78	
T	Eucalyptus globulus	0	0	5	11	14	25	0	22	
Cl	Comesperma volubile	13	8	0	10	14	10	15	0	
S	Acacia verticillata	0	0	0	0	9	50	46	33	
H	Acaena agnipila	0	8	2	5	9	40	31	22	
S	Goodenia ovata	0	0	0	5	0	65	23	56	
H	Haloragis teucrioides	0	8	15	16	68	90	85	67	
F	Pteridium esculentum	0	23	0	53	86	75	77	100	
Cl	Billardiera longiflora	0	0	2	0	14	15	8	0	
S	Helichrysum thyrsoideum	0	0	10	5	73	90	8	33	8
S	Olearia spp.	0	0	5	0	36	60	0	44	
Cl	Bauera rubioides	0	0	0	0	0	0	15	11	
H	Geranium potentilloides	0	15	0	11	32	10	77	89	
Gr	Drymophila cyanocarpa	0	0	0	5	5	10	15	56	
S	Olearia viscosa	0	0	0	0	0	0	8	44	
S	Coprosma quadrifida	0	8	5	0	9	25	0	89	

Additional species (of rare occurrence) recorded during the floristic survey :

Acacia melanoxylon, T; A. verniciflua, S; Acianthus caudatus, O; Anguillaria dioica, Gr; Blechnum minus, F; Centaurium pulchellum, H; Clematis aristata, Cl; Coprosma hirtella, S; Cyathodes divaricata, S; Cymbonotus lawsonianus, H; Echinopogon ovatus, G; Epacris tasmanica, S; Epilobium sarmentaceum, H; Eucalyptus brookerana A.M. Gray, T; E. cordata, T; Exocarpos cupressiformis, T; Gleichenia dicarpa, F; Helichrysum dendroideum, S; Hibbertia empetrifolia, S; Histiopteris incisa, F; Hydrocotyle sibthorpioides, H; Juncus spp, Gr; Laxmannia sessiliflora, Gr; Lepidosperma filiforme, Gr; Leptorhynchos linearis, H; Leptospermum lanigerum, S; Lycopodium deuterodensum, F; Microseris scapigera, H; Notelaea ligustrina, S; Olearia phlogopappa, S; O. ramulosa, S; Phyllanthus australis, S; Pimelea drupacea, S; Poa annua, G; Polystichum proliferum, F; Pomaderris apetala, S; Prostanthera lasianthos, S; Ranunculus sp., H; Sonchus oleraceus, H; Sphaerolobium vimineum, S; Tetratheca pilosa, S; T. procumbens, S; Veronica gracilis, H.

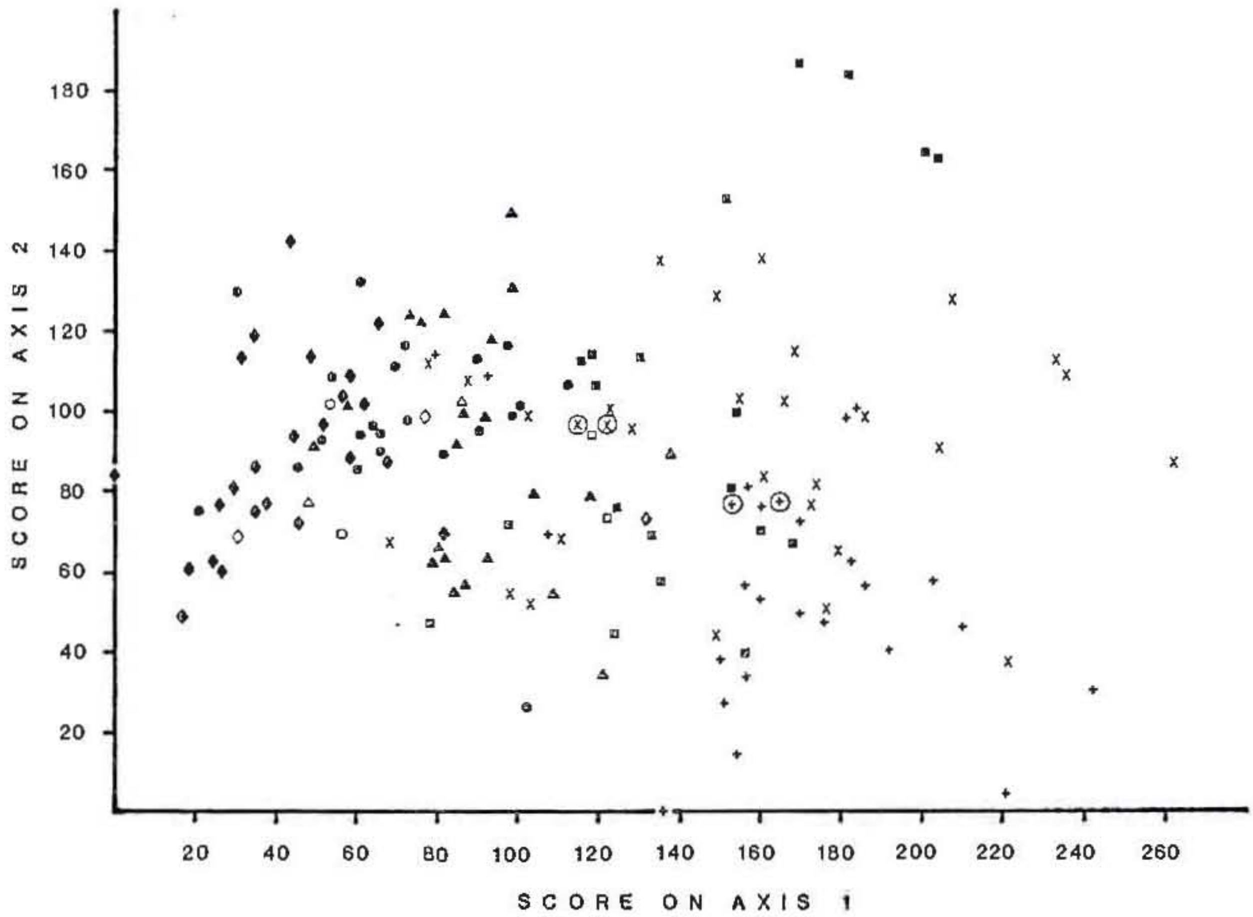


Fig. 11 : Graph of the first and second axis ordination scores derived using detrended correspondence analysis, for each of the quadrats sampled during the floristic survey at MM14.

X = Treatment B : Type O; ⓧ = Treatment B permanent plots : Type O;
■ = Treatment UB : Type O; □ = Treatment UB permanent plots : Type O;
+ = Control : Type O; ⊕ = Control permanent plots : Type O.

● = Treatment B : Type P; ○ = Treatment B permanent plots : Type P;
▲ = Treatment UB : Type P; △ = Treatment UB permanent plots : Type P;
◆ = Control : Type P; ◇ = Control permanent plots : Type P.

1979a). The classification is complemented by the detrended correspondence analysis (DCA) depicted in Fig. 11 with the first and second axis ordination scores plotted for each of the quadrats surveyed.

Type O quadrats generally have high scores on axis 1 (Fig. 11). Conversely, type P plots are characterised by medium to low axis 1 results. Field locations of the surveyed quadrats together with their approximate axis 1 score are shown in Fig. 12.

The unidimensional ordination provided by the TWINSPAN classification procedure reveals a similar picture to the first axis of the DCA. Type O quadrats, consisting mainly of quadrat groups 5 to 8, are separated almost *in toto* from those in type P, which lie mainly in groups 1 to 4 (Table 3).

The separation of the classified quadrat groups is less well-defined on the second axis of ordination than on the first. However, quadrats occurring on poorly-drained, occasionally waterlogged sites have high axis 2 scores, whereas plots with low scores were sampled from well-drained positions.

Type O quadrats are more dispersed on both ordination axes than those of type P. This phenomenon reflects the greater range in environmental conditions covered by type O plots at MM14. The permanent quadrats have medium second axis scores and low to medium axis 1 positions (Fig. 11).

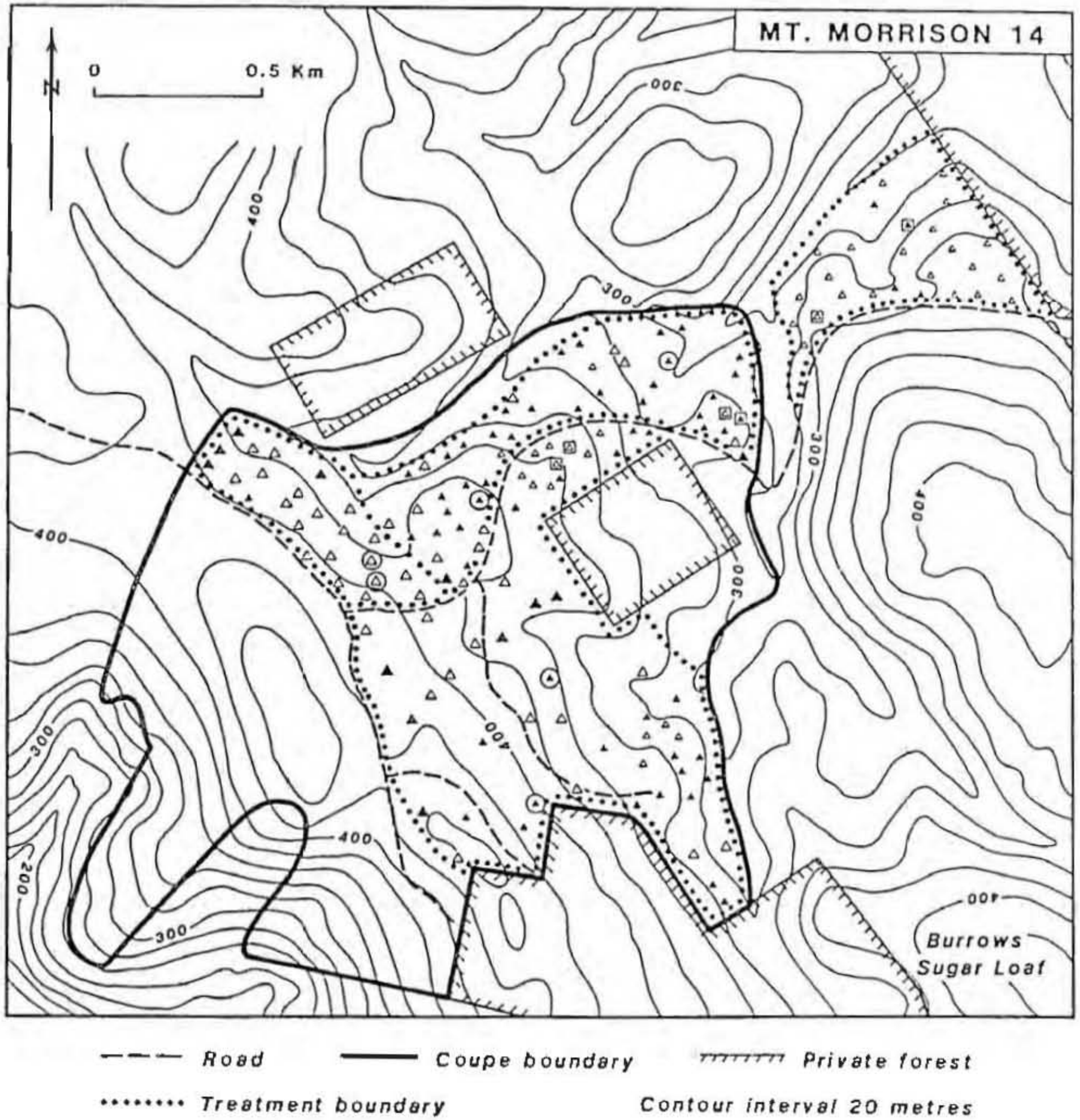
Levels 2 and 3 in the quadrat classification progressively differentiate the well-watered or poorly-drained sites from those with least moisture availability. The extremes of wet and dry fall in groups 8 and 1 respectively (Table 3). Groups 7 and 8 encompass quadrats with either high first axis or high second axis ordination scores. The permanent plots all fall within groups 1 to 6. The type P permanent plots are classified into groups 1 to 4, while the type O permanent

Fig. 12 :
The field location of the quadrats sampled during the floristic survey at MM14. Each quadrat is represented by one of four classes corresponding to the axis 1 ordination score derived using detrended correspondence analysis. For the area and extent of the particular treatments and controls see Fig. 3.

○ = Type O permanent plots;

□ = Type P permanent plots.

	Axis 1 ordination score
△ =	0 - 66
▲ =	67 - 132
△ =	133 - 198
▲ =	198 - 264



plots are classified into groups 4 to 6. Group 4 includes the floristically surveyed quadrats which were transitional between type P and type O. The ordination and classification indicated that the permanent quadrats did not occur in the areas with extremes of moisture availability and drainage in the region of MM14. Thus, the plots could be assumed to be representative of the average ecological range within the local dry forest types.

The species classification divides on those species which are characteristic of the extremes of moisture availability. Species such as Hibbertia riparia, Lissanthe strigosa and Bossiaea prostrata have their frequencies of occurrence weighted towards groups 1 to 4. At the other extreme Coprosma quadrifida, Olearia viscosa and Drymophila cyanocarpa have their highest frequencies in quadrat groups 6 to 8 (Table 3).

Species group 4 encompasses a large number of species which are ubiquitous (Table 3). For example the grasses such as Agrostis spp., Deyeuxia spp., Microlaena stipoides, Pentapogon/Dichelachne occur throughout the moisture gradient.

2.5.2 Permanent plots

2.5.2.1 Selection

With the exception of type O, Selection 1, $\geqslant$ 70% floristic similarity was achieved between the permanent quadrats on treatments B and UB and the controls (Table 4). In the case of type O, Selection 1, 67% was accepted as the best available comparison between treatments B and UB which complied with the species number specification stated in section 2.3.2. The 12 permanent plots which were selected are shown in Plates 2 and 3.

	% similarity between permanent quadrats		
	Comparisons		
Vegetation type	B : UB	B : C	UB : C
P			
Selection 1	89	82	73
Selection 2	77	72	81
O			
Selection 1	81	70	67
Selection 2	83	74	80

<u>TABLE 4</u>: Percentage floristic similarity between treatments and controls, for the selected permanent quadrats in each vegetation type at MM14.

P = <u>E.pulchella</u> dominated; O = <u>E.obliqua</u> dominated;
B = clearfelled, slash-burnt; UB - clearfelled, slash-unburnt;
C = uncut, control forest.

2.5.2.2

(1) Cover of recorded descriptive features

The mean percentage cover of bare ground through time in each vegetation type, treatment and control is shown in Fig. 13a. The cover of bare ground was greater in the type P and type O permanent plots on treatment B, than in the plots on treatment UB or the control sites. Bare ground on treatment B was greater in the type P permanent plots than in the plots in type O until 16 months after the slash-burn. From 16-24 months after the slash-burn the percentage bare ground on treatment B equalised in the two vegetation types. The cover on treatment B of material within the miscellaneous category consisting of charred wood and plant material (Fig. 13a), remained approximately constant on type P plots from 1-24 months after the slash-burn, but decreased rapidly on type O plots. However, the cover of material within this miscellaneous category was greater in type O than in type P plots throughout the 24 months of study (Fig. 13a).

The percentage cover of other recorded descriptive features is presented in Table 5. Type O, treatment UB, has higher slash cover consisting of leaves, twigs and small branches than type P, treatment UB. However, log cover is similar in the two cases. Type O, treatment B, has similar log cover to type O, treatment UB.

Rock cover is greatest in the type P control, and in type O, treatment B. Litter cover is greater on the control plots than on treatment UB due to the presence of slash on the latter which obscured the ground litter layer.

Plate 2 :

(A) Two months after the slash-burn (March 1982): the permanent plot chosen from type O, treatment B as part of Selection 1 (Table 4). This permanent plot is referred to as Plot 2 (see Fig. 16). The layout of the quadrat (see diagram Fig. 4(a)) is shown marked by tape, with the central corridor (0.5m width) which was omitted from recording. Plant cover is extremely low with large areas of exposed rock and bare ground.

(B) The same permanent plot as shown in (A), 24 months after the slash-burn. Plant cover is well developed although cover of bare ground remains high. The lighter areas in the foreground correspond to the mechanically disturbed edges of a snig track. The principal species which can be seen in the photograph are Senecio minimus (centre left), Eucalyptus obliqua (middleground) and Lomandra longifolia (centre right). The fenced exclosure (pictured for the same recording occasion in Plate 4(B)) can be seen in the background near to the permanent plot.

(C) Two months after the slash-burn (March 1982): the permanent plot chosen from type O, treatment B as part of Selection 2 (Table 4). This permanent plot is referred to as Plot 1 (see Fig. 16). Coarse fuel remains following the fire. Large areas are covered by charred material or are bare, although some plant cover has already developed.

(D) The same permanent plot as shown in (C), 24 months after the slash-burn (January 1984). The photograph is taken from a position closer to the quadrat due to the view shown in (C) having been obscured by the growth of epicormic shoots on a nearby tree trunk. Plant cover (mainly Gahnia grandis) has increased dramatically. Snig tracks (top right) remain unvegetated.

(E) Two months after the slash-burn (March 1982): the permanent plot chosen from type P, treatment B as part of Selection 1 (Table 4). This permanent plot is referred to as Plot 1 (see Fig. 16). Coarse fuel remains following the burn, which was patchy and of low intensity.

(F) The same permanent plot as shown in (E), 24 months after the slash-burn (January 1984). Cover of tussock grasses (mainly Poa spp.) has developed, together with vigorous coppice growth from the eucalypt stump shown in the top left of the photograph (see section 2.5.2.2 ; group 4(i)). The fenced exclosure (pictured for the same recording occasion in Plate 4(D)) can be seen on the left of the photograph.

(G) Two months after the slash-burn (March 1982): the permanent plot chosen from type P, treatment B as part of Selection 2 (Table 4). This permanent plot is referred to as Plot 2 (see Fig. 16). Coarse fuel remains following the slash-burn, together with large areas of exposed rock and bare ground.

(H) The same permanent plot as shown in (G), 24 months after the slash-burn (January 1984). Plant cover is well developed, particularly of graminoid species. Eucalypt regeneration is poor.

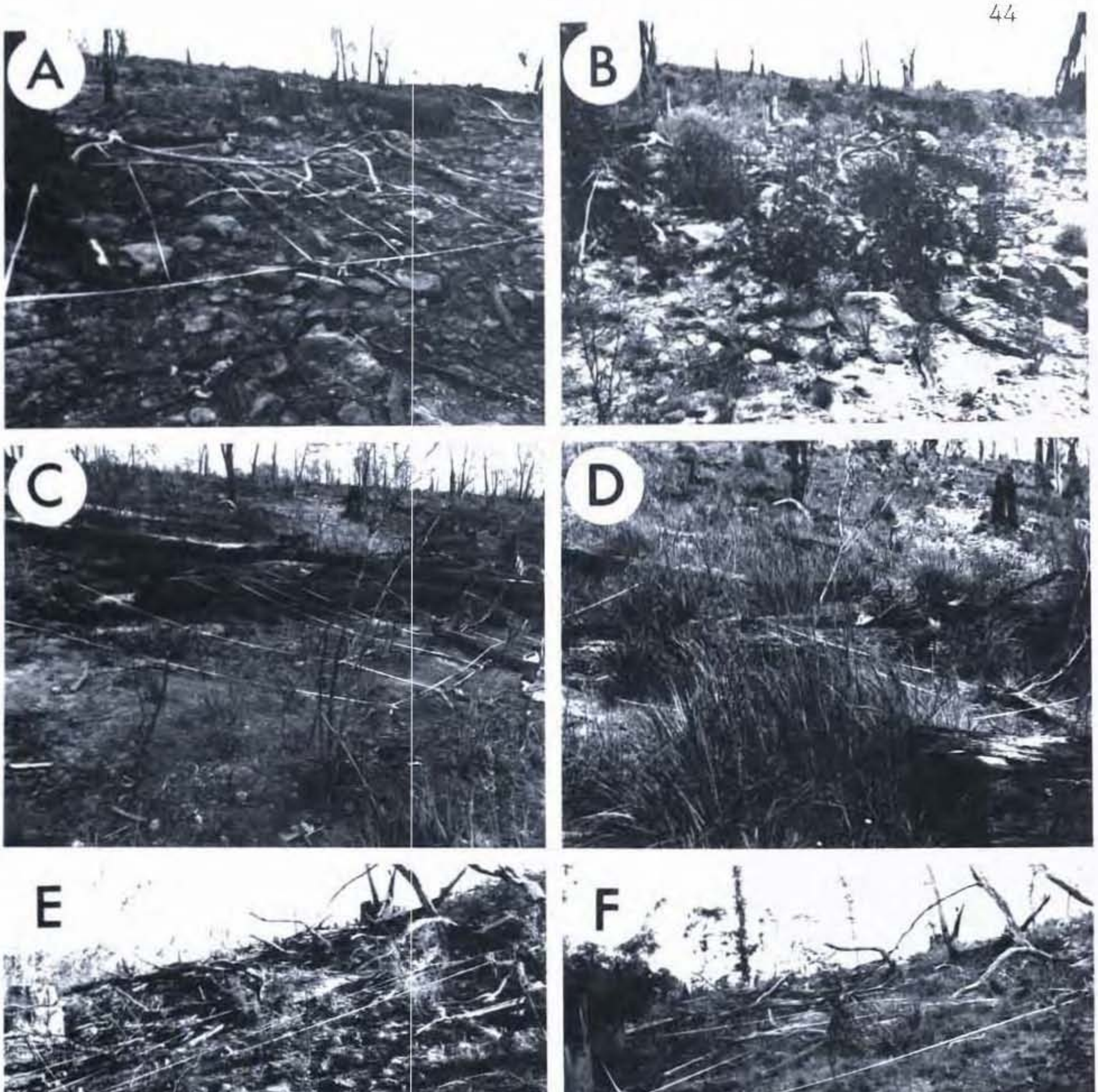

A
B
C
D
E
F
G
H

TABLE 5: Percentage cover of four descriptive features recorded on the permanent plots in each vegetation type, treatment and control.

		Percentage cover of descriptive feature			
Vegetation type	Treatment/ control	Rock	Logs	Slash (leaves, twigs etc)	Litter
P	B	7.6	5.0	-	-
	UB	5.0	15.0	2.0	32.6
	C	16.0	5.9	-	39.7
O	B	10.6	11.6	-	-
	UB	2.5	16.0	25.0	24.0
	C	2.0	3.0	-	26.8

Plate 3 :

(A) The permanent plot chosen from type O, treatment UB as part of Selection 1 (Table 4), 24 months after the time of the slash-burn (January 1984). Much of the quadrat was covered by slash which made access difficult. Advanced growth of eucalypts can be seen in the background of the photograph.

(B) The permanent plot chosen from type O, treatment UB as part of Selection 2 (Table 4), 24 months after the time of the slash-burn. Part of this quadrat is covered by the remains of a lopped E. obliqua head, which was left after the logging operation.

(C) The permanent plot chosen from type O, control C as part of Selection 2 (Table 4), 24 months after the time of the slash-burn. The mature eucalypts shown are all E. obliqua. The shrubby understorey is 1m to 2m tall.

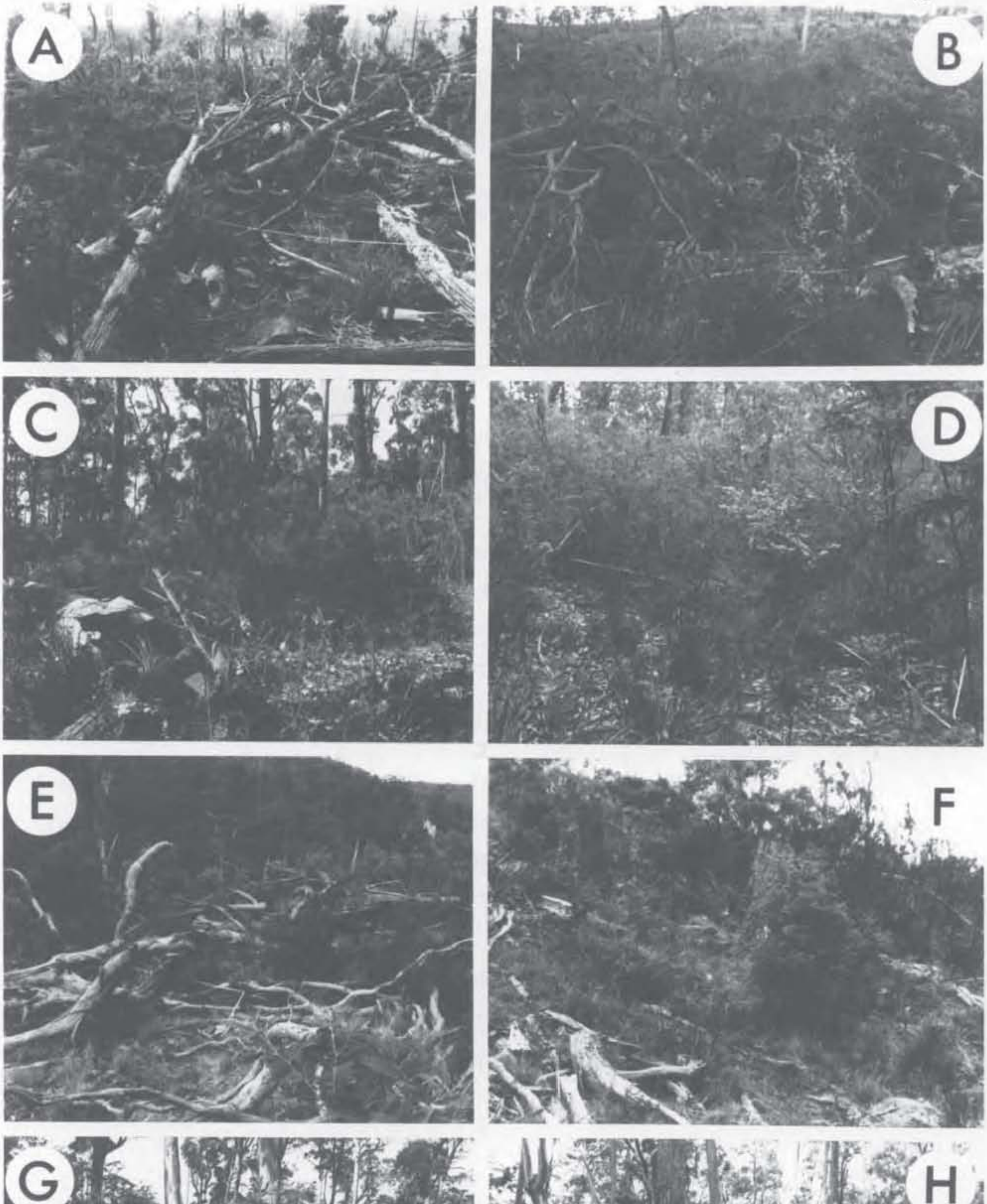
(D) The permanent plot chosen from type O, control C as part of Selection 1 (Table 4), 24 months after the time of the slash-burn. The shrubby understorey is 1m to 2.5m tall.

(E) The permanent plot chosen from type P, treatment UB as part of Selection 1 (Table 4), 24 months after the time of the slash-burn. Cover by slash composed of leaves, twigs and small branches was lower than on the plots in type O (see Table 5).

(F) The permanent plot chosen from type P, treatment UB as part of Selection 2 (Table 4), 24 months after the time of the slash-burn. Type P plots had greater grass cover than present on the type O plots.

(G) The permanent plot chosen from type P, control C as part of Selection 1 (Table 4), 24 months after the time of the slash-burn. The dominant shrub is Acacia dealbata (background), the graminoid in the foreground is Lomandra longifolia. The mature eucalypts shown are dominantly E. pulchella with the occasional E. viminalis.

(H) The permanent plot chosen from type P, control C as part of Selection 2 (Table 4), 24 months after the time of the slash-burn. The mature eucalypts shown are E. pulchella (smooth-barked) and E. amygdalina (rough-barked).


A
B
C
D
E
F
G
H

(2) Species cover

Changes in cover during the 24 months of detailed study on each of the permanent plots on treatment B are shown in Plate 2. Change in cover viewed from point X (Fig. 3) is shown in Plate 1.

The relative changes in mean percentage cover of individual species on the permanent plots, in each vegetation type, treatment and control, are shown in Fig. 13b. Species growth response may be approximately grouped into 6 categories based on the speed of recovery or establishment of the particular species after the slash-burn, and the subsequent rapidity of growth. The mean percentage cover of each species in each vegetation type, treatment and control are given for the 6 categories in Appendix 3.

+ Treatment B : Type P cover > Type O 24 months post-burn
= Treatment B : Type P cover = Type O 24 months post-burn
- Treatment B : Type P cover < Type O 24 months post-burn

Lifeform: Cl = climber; F = fern; G = grass;
Gr = graminoid; H = herb; O = orchid;
S = shrub; T = tree.
(* = exotic species).

Group 1

This group consists of species which established rapidly after the slash-burn on treatment B. The species maintained steady growth increases on treatment B until 8 months post-fire and then showed marked rapid growth from 8-24 months.

(i) This subgroup includes species which maintained little or no growth on treatment UB and the control C, in either type P or type O.

G	Agrostis parviflora	-
G	A. venusta	+
H	Gnaphalium collinum	-
Gr	Lomandra longifolia	+
S	Lomatia tinctoria	+
Gr	Schoenus apogon	=
H	Senecio minimus	-
G	Stipa spp.	+
H	Viola hederacea	-

(ii) This subgroup contains species which showed marked fluctuations in cover on treatment UB and the control C, in both vegetation types.

F	Pteridium esculentum	-

Group 1 contd.

(iii) The species within this subgroup maintained gradual or steady growth increases on treatment UB and the control C, in both vegetation types.

G	Agrostis aemula	=
H	*Cirsium vulgare	-
T	Eucalyptus obliqua	-
Gr	Gahnia grandis	-
H	*Hypochaeris radicata	=

(iv) Species within this subgroup showed rapid growth on treatment UB from 8-24 months after the time of the slash-burn in both vegetation types.

G	Danthonia spp.	=
H	Haloragis tetragyna	+
H	Plantago varia	+

Group 1 contd.

(v) In this case the general growth response of the species differed between types P and O. In type P there was rapid growth from 4-16 months on treatments B and UB, whilst in type O there was rapid growth on treatment B from 16-24 months but a decrease on the control C.

G *Pentapogon*/*Dichelachne* =

Group 2

This group consists of species which established rapidly after the slash-burn on treatment B but lacked the marked rapid growth response of the species in group 1.

(i) This species maintained a steady growth increase on treatment B, with an initial increase on treatment UB but some decline on the control C.

G *Poa* spp. +

(ii) As in the case of (i) this species maintained a steady growth increase on treatment B, but on treatment UB there was rapid growth whilst remaining steady on the control C.

H *Hydrocotyle javanica* –

Group 2 contd.

(iii) Species within this subgroup showed some initial growth increase from 0-8 months on treatment B followed by a gradual increase from 8-24 months. There was some fluctuation in cover on treatment UB and the control C.

S	Acacia dealbata	+
G	Deyeuxia spp.	+
H	Helichrysum scorpioides	+
S	Leptospermum scoparium	+
S	Lissanthe strigosa	+

(iv) This subgroup includes species which showed little growth from 0-8 months on treatment B followed by a gradual increase from 8-24 months, with increases on both treatment UB and the control C.

Gr	Diplarrena moraea	-
Gr	Lepidosperma laterale	-
G	Festuca asperula	+

Group 3

This group consists of species which established rapidly after the slash-burn on treatment B but showed some fluctuation in growth over the 24 months of study.

(i) Species within this subgroup showed fluctuation in growth but an overall increase from 0-24 months on treatment B. Growth was either steady or increased slightly on treatment UB or the control C.

G	Microlaena stipoides	=
S	Bossiaea prostrata	+

(ii) This subgroup includes species which grew rapidly from 0-4 months on treatment B, fluctuated from 4-16 months and then grew steadily from 16-24 months. There were slight fluctuations in growth on treatment UB and the control C.

H	Goodenia lanata	+
H	Opercularia varia	-

(iii) This species showed very slight growth on treatment B but marked rapid growth on treatment UB.

T	Eucalyptus amygdalina	+

Group 4

This group consists of species which showed delayed establishment on treatment B following the slash-burn.

(i) Species within this subgroup established from 2-4 months after the slash-burn on treatment B and showed marked rapid growth from 16-24 months. There was some growth increase on treatment UB if the species was present.

H	Acaena novae-zelandiae	=
H	*Leontodon leysseri	+
S	Olearia sp.	+
T	#Eucalyptus pulchella	+

(# = record due to the cover of coppice from a stump adjacent to the quadrat boundary).

(ii) This subgroup includes species which established from 2-8 months after the slash-burn on treatment B. There was some fluctuation in growth on treatment UB if the species was present.

S	Olearia ramulosa	=
H	*Sonchus asper	-
H	Helichrysum dealbatum	+

(iii) This species established from 12-16 months post-burn on treatment B but showed little change in cover thereafter.

H	Oxalis corniculata	=

Group 4 contd.

(iv) This species established from 4-8 months after the slash-burn on treatment B and then grew steadily to 24 months. The species established between 16-24 months on treatment UB.

H	*Epilobium sarmentaceum*	–

(v) This species established from 4-16 months on treatment B, and showed a decrease in cover in the type 0 control.

S	*Helichrysum thyrsoideum*	=

(vi) Species within this subgroup showed only slight growth on treatment B with generally slight changes on treatment UB and the control C.

S	*Astroloma humifusum*	+
S	*Cyathodes glauca*	–
S	*Epacris impressa*	–
H	*Pratia pedunculata*	–

Group 5

This group consists of species which established rapidly after the slash-burn on treatment B but subsequently showed either little growth or a decline in cover.

(i) Species within this subgroup showed slight changes in cover on treatment UB and the control C.

Gr	*Arthropodium milleflorum*	=
Gr	*Carex breviculmis*	+
Gr	*Dianella tasmanica*	-
H	*Galium albescens* and *G. australe*	+
H	*Hypericum gramineum*	=
H	*Lagenophora stipitata*	=
S	*Olearia erubescens*	+
S	*Pimelea humilis*	+
H	*Stylidium graminifolium*	+
H	*Wahlenbergia* spp.	+

(ii) Species within this subgroup showed marked fluctuations or decline in cover on treatment UB and the control C.

S	*Acacia stricta*	-
S	*Pultenaea juniperina*	-

(iii) This subgroup includes species which showed seasonal disappearance and reappearance.

H	*Drosera auriculata*	=
O	Orchidaceae spp.	=

Group 6

This group consists of species which showed either very delayed, or no establishment on treatment B.

(i) The species within this subgroup were not present on treatment B before or after the slash-burn. Their cover showed some change on treatment UB and the control C.

Cl	Comesperma volubile	-
Gr	Dianella revoluta	-
T	Eucalyptus globulus	-
Gr	Lepidosperma lineare var. inops	+
Gr	Leptorhyncos squamatus	+
H	Poranthera microphylla	=
S	Tetratheca glandulosa	-

(ii) These species were not present before the slash-burn on treatment B. Where present, the species generally declined in cover on treatment UB or the control C.

S	Daviesia ulicifolia	+
H	Haloragis teucrioides	-

(iii) This species was present before the slash-burn on treatment B but was not recorded afterwards.

G	Themeda australis	+

Fig. 13 (a)

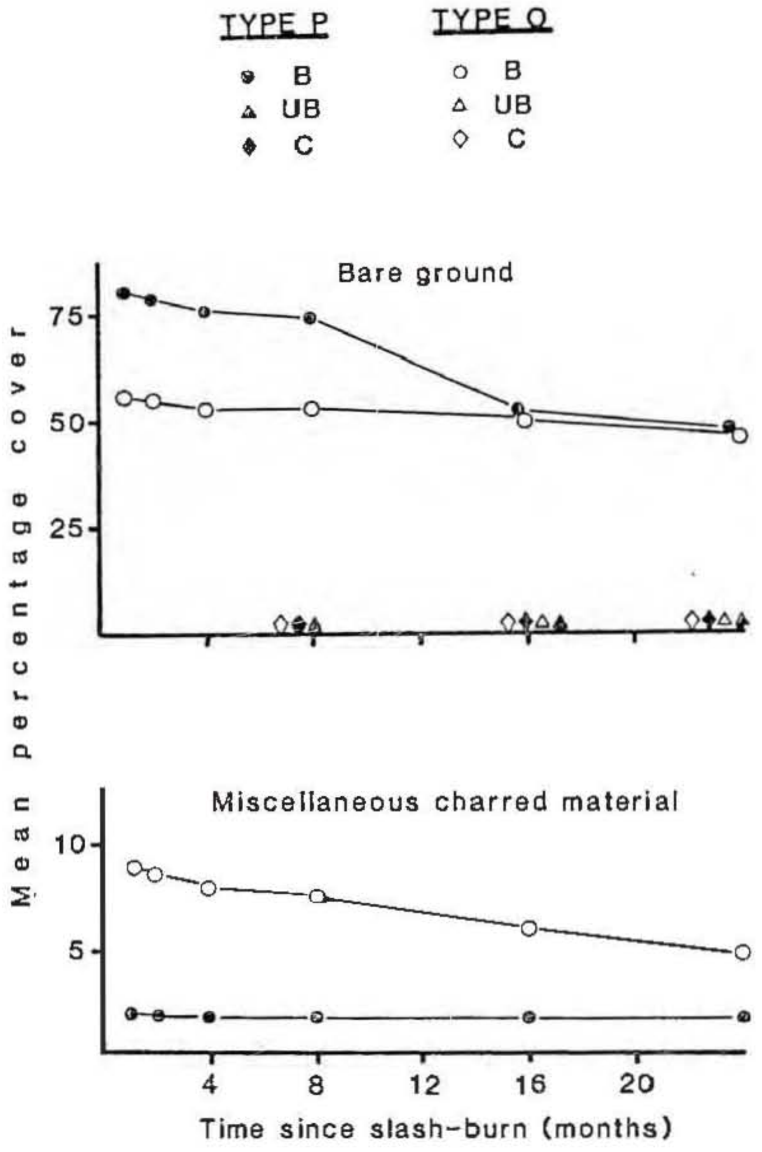

TYPE P
B
UB
C
TYPE Q
B
UB
C
Bare ground
75
50
25
Mean percentage cover
Miscellaneous charred material
10
5
4
8
12
16
20
Time since slash-burn (months)

Fig. 13 (b)

GROUP 1 (i)

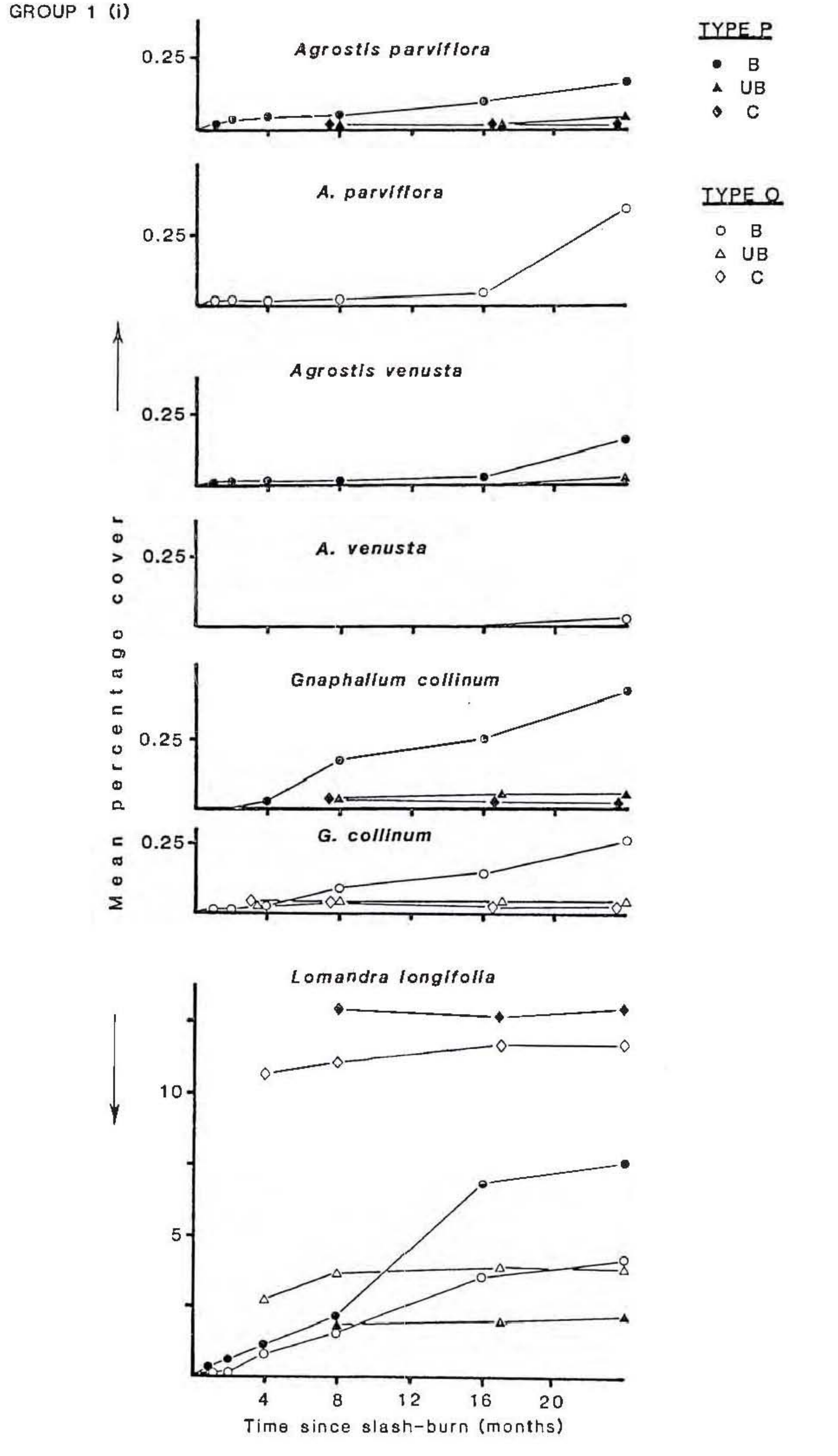


Fig. 13 (b) contd.

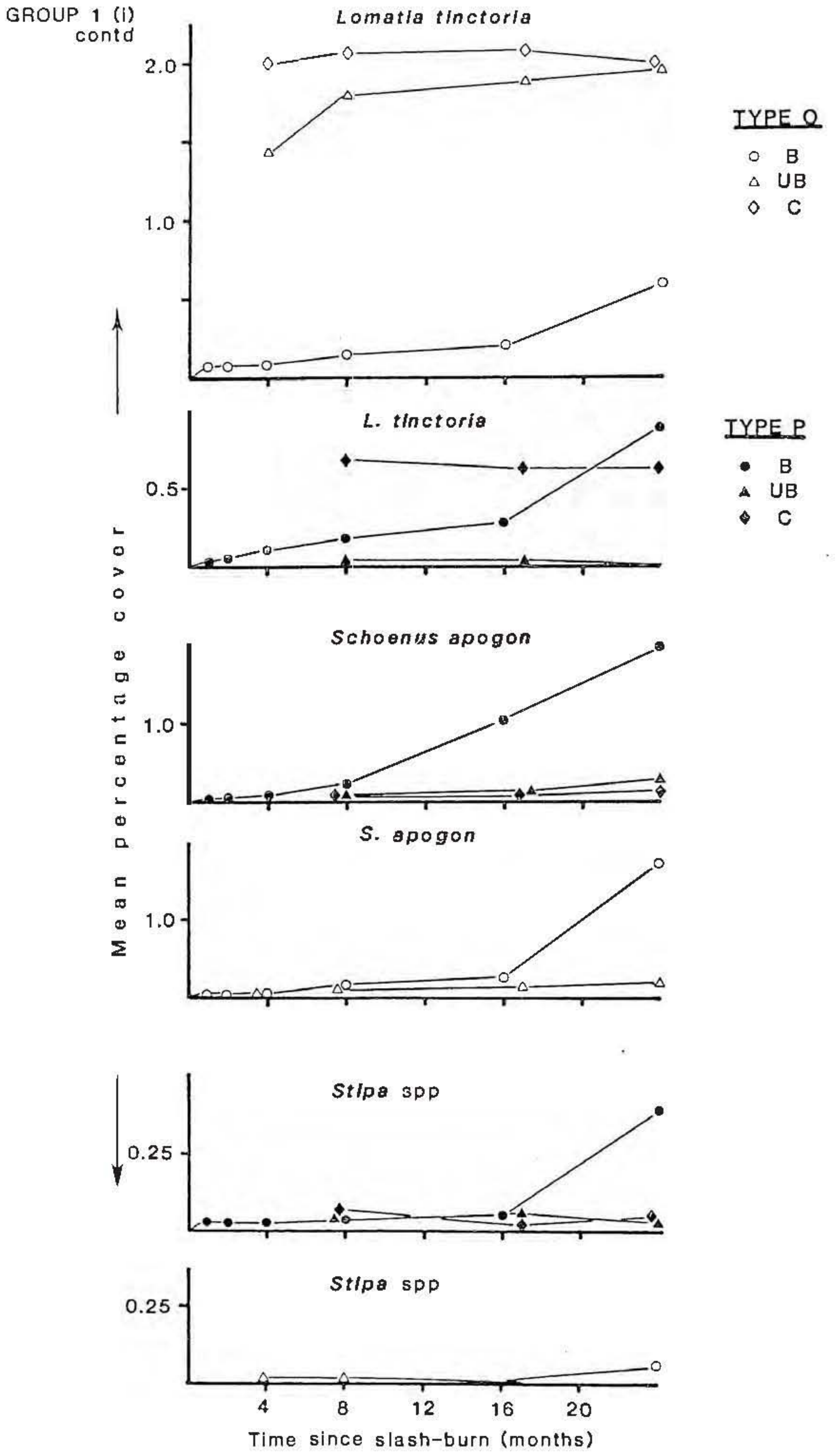


Fig. 13 (b) contd

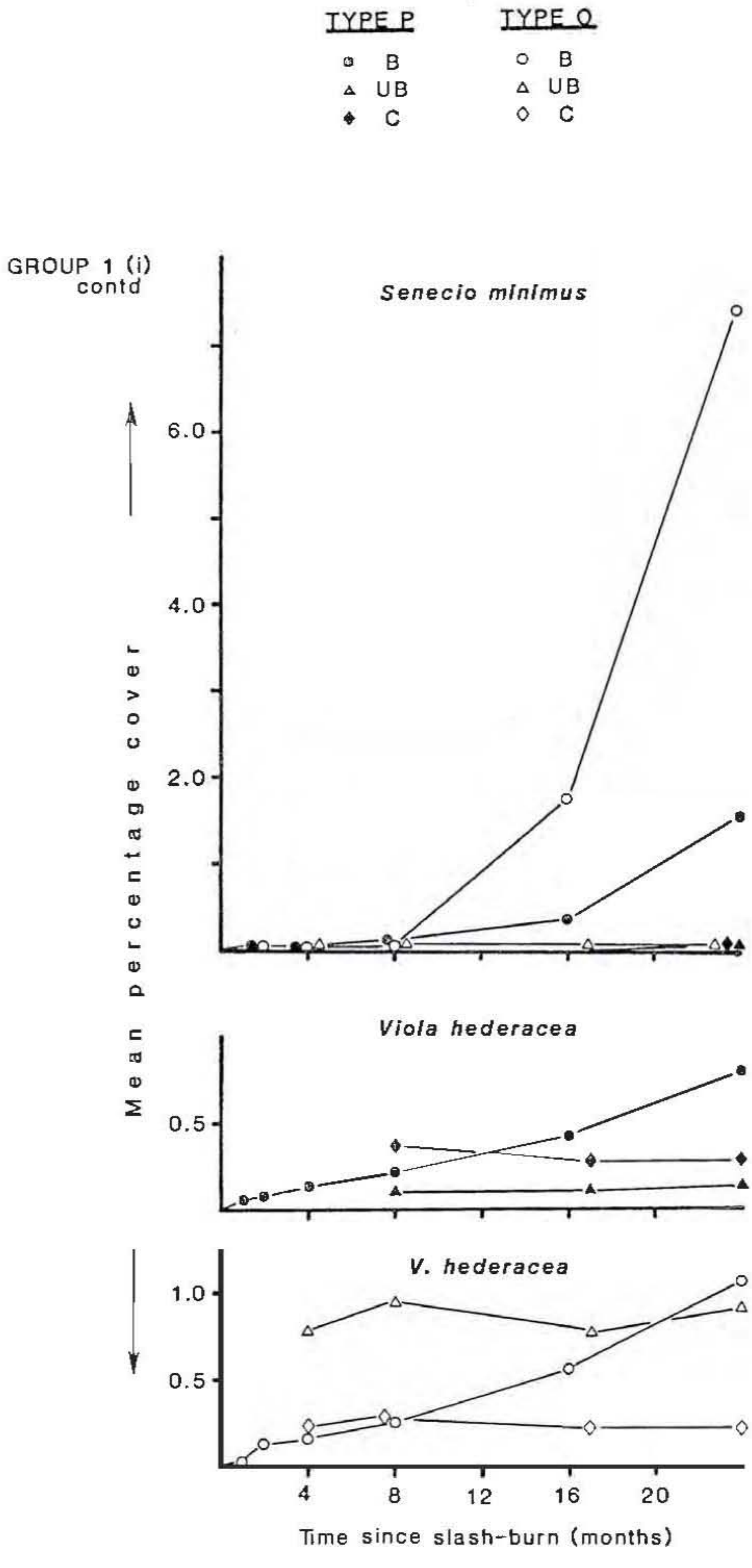


Fig. 13 (b) contd.

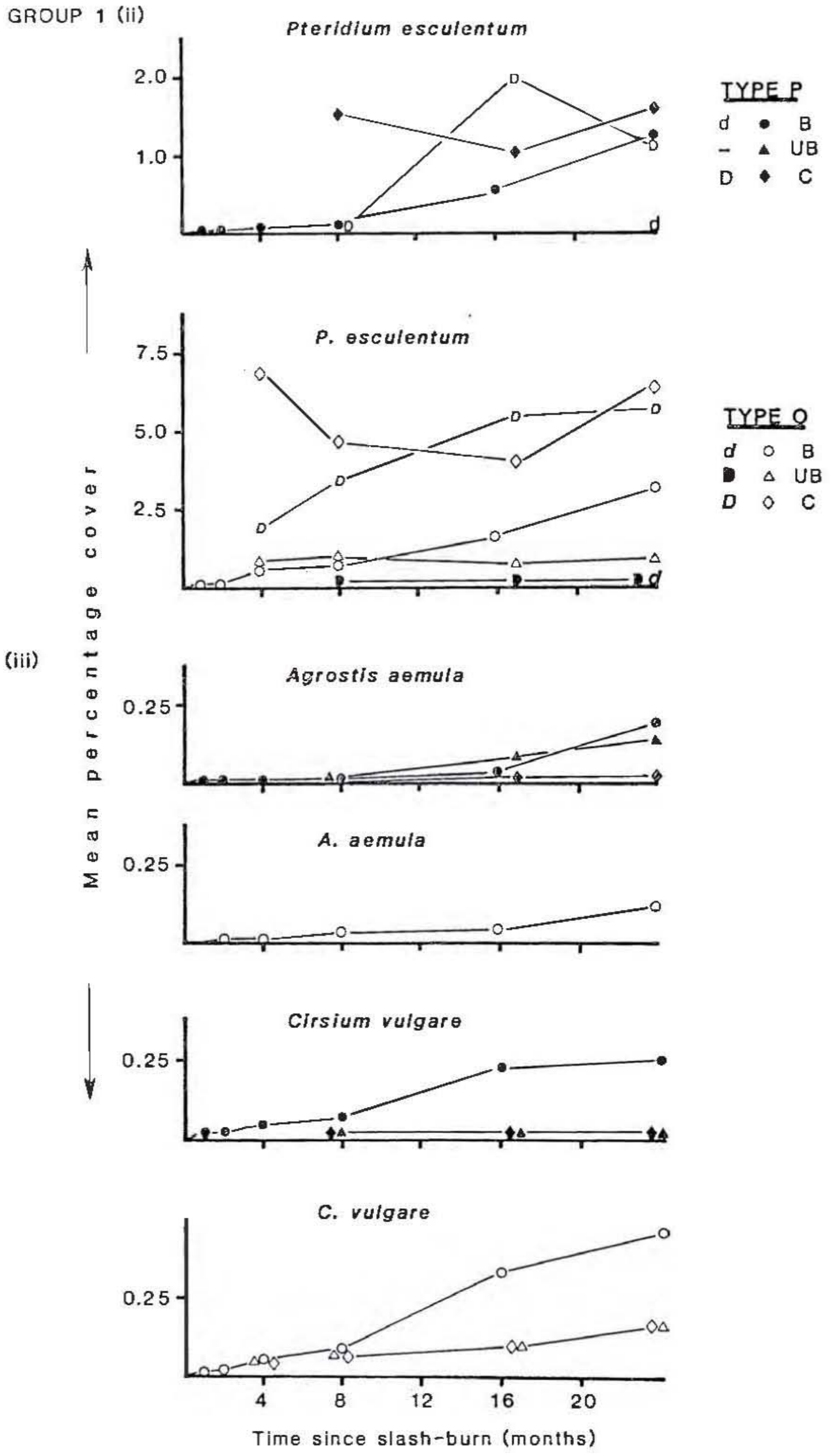


Fig. 13 (b) contd.

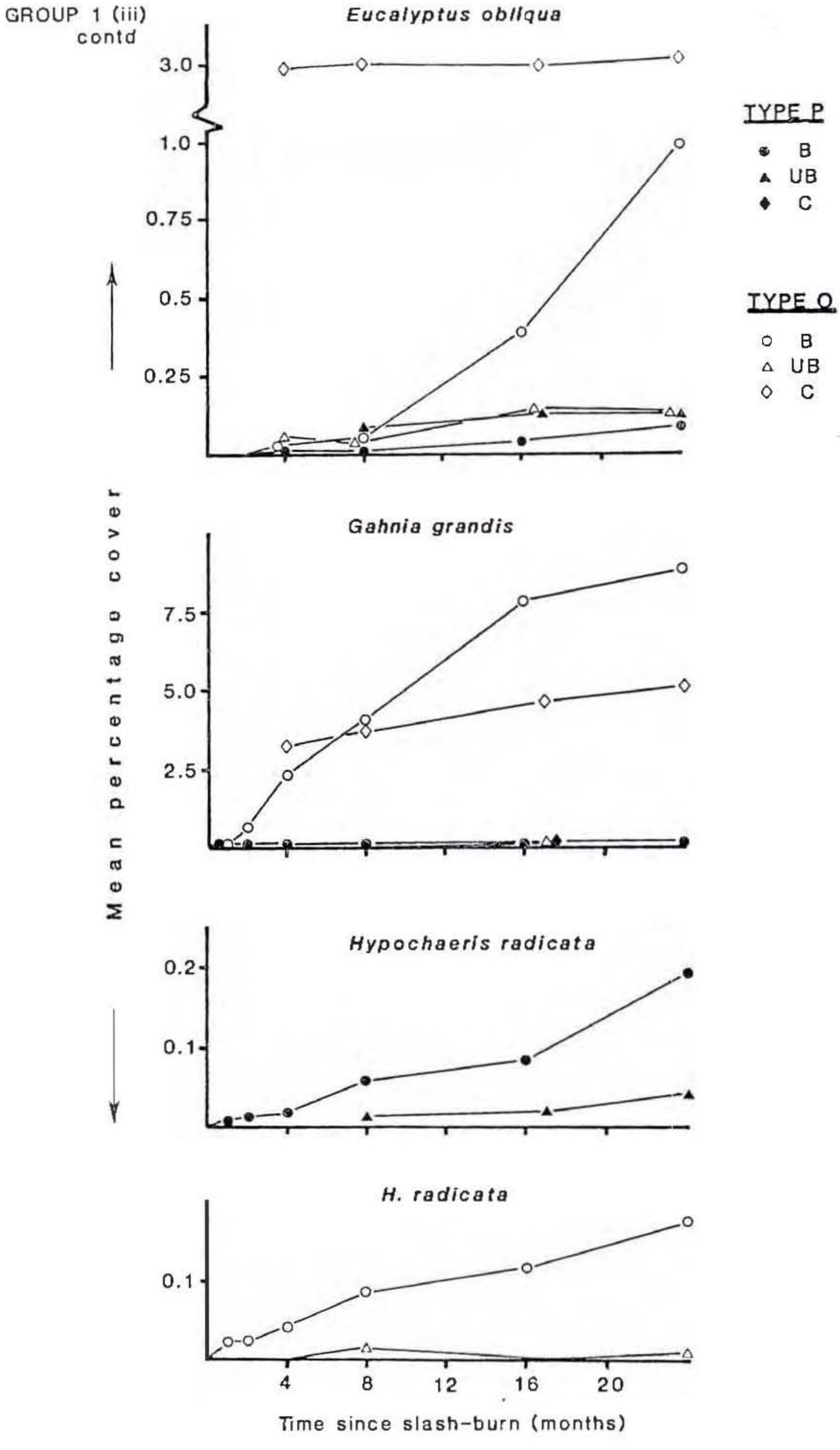
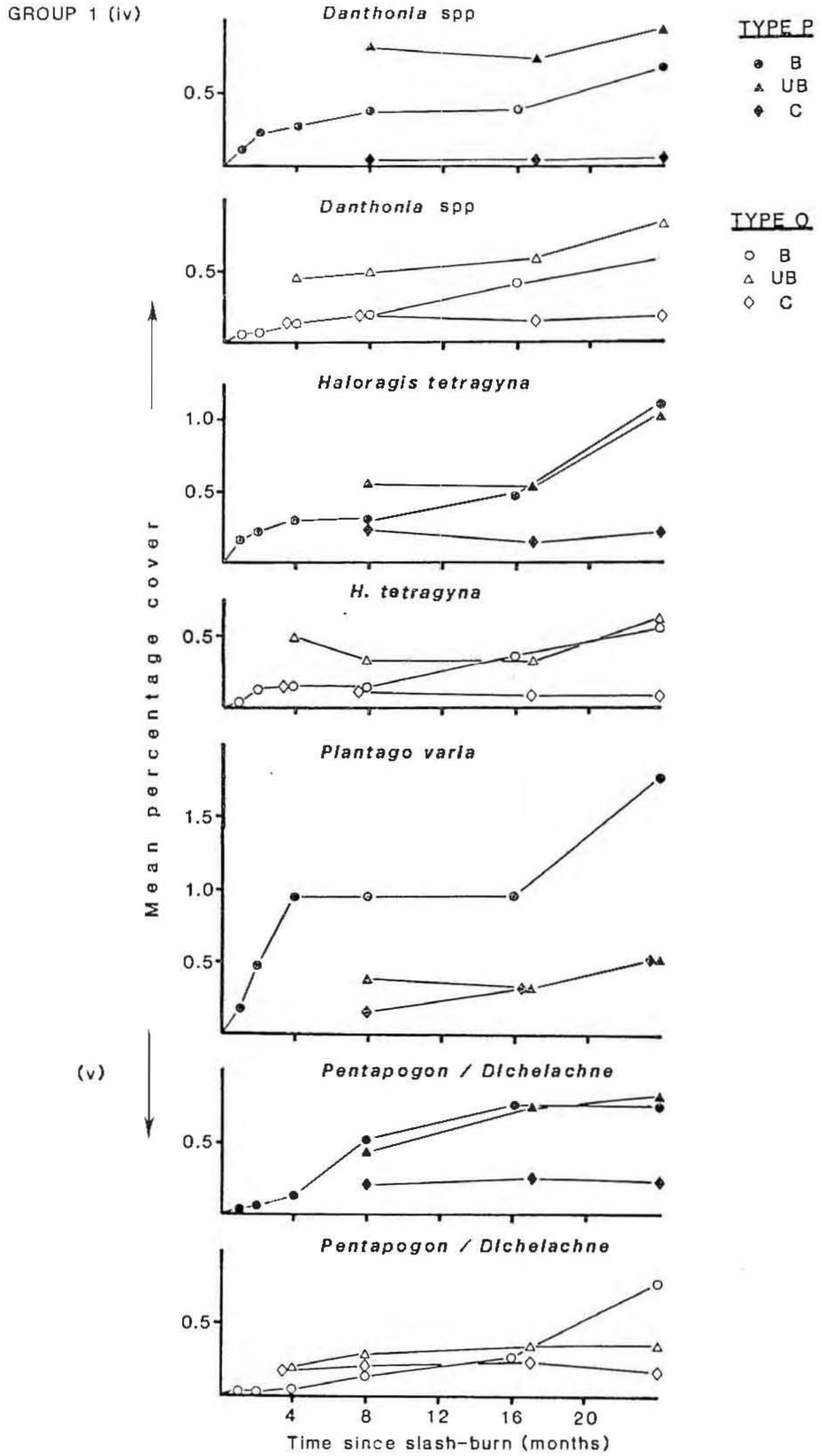


Fig. 13 (b) contd.



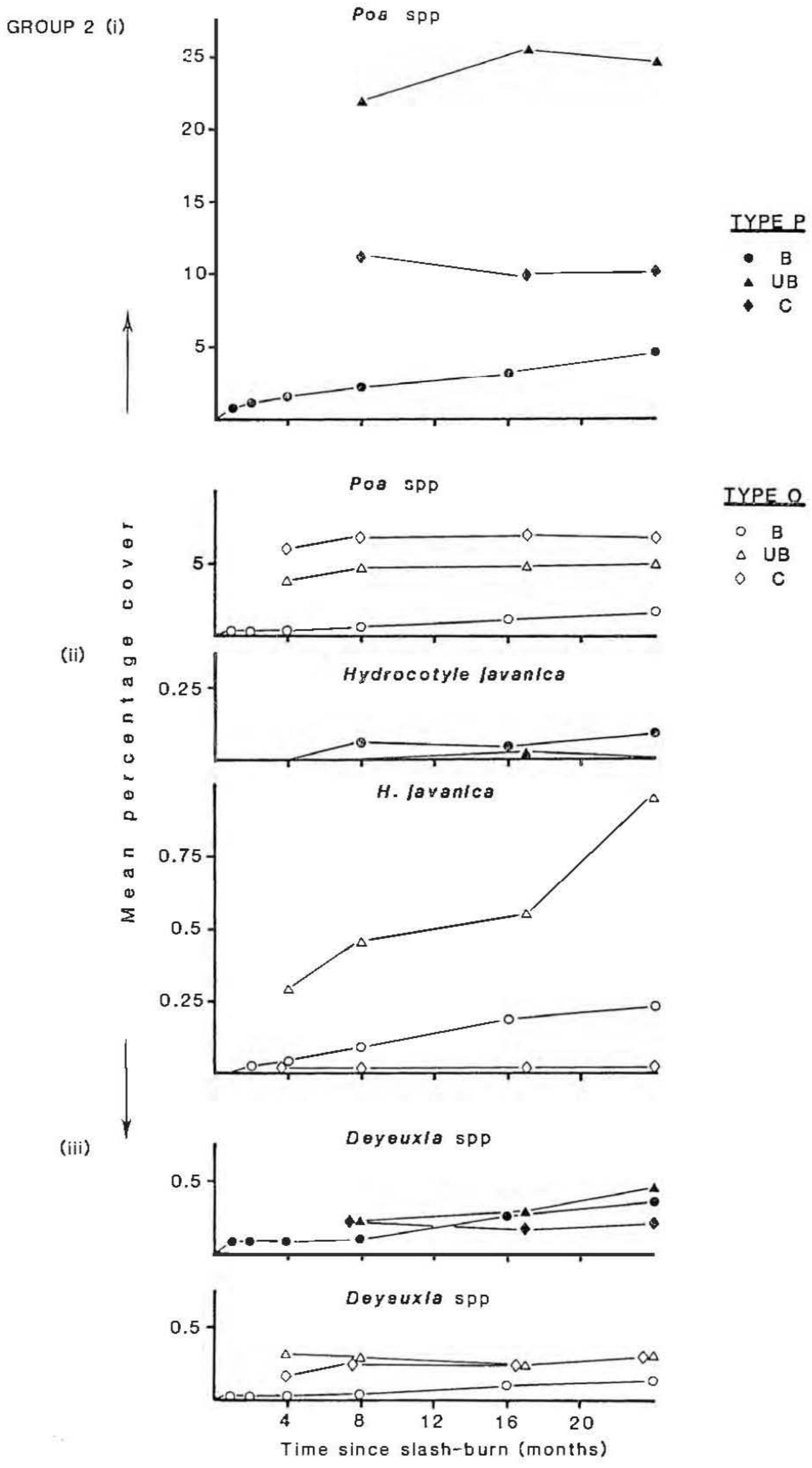
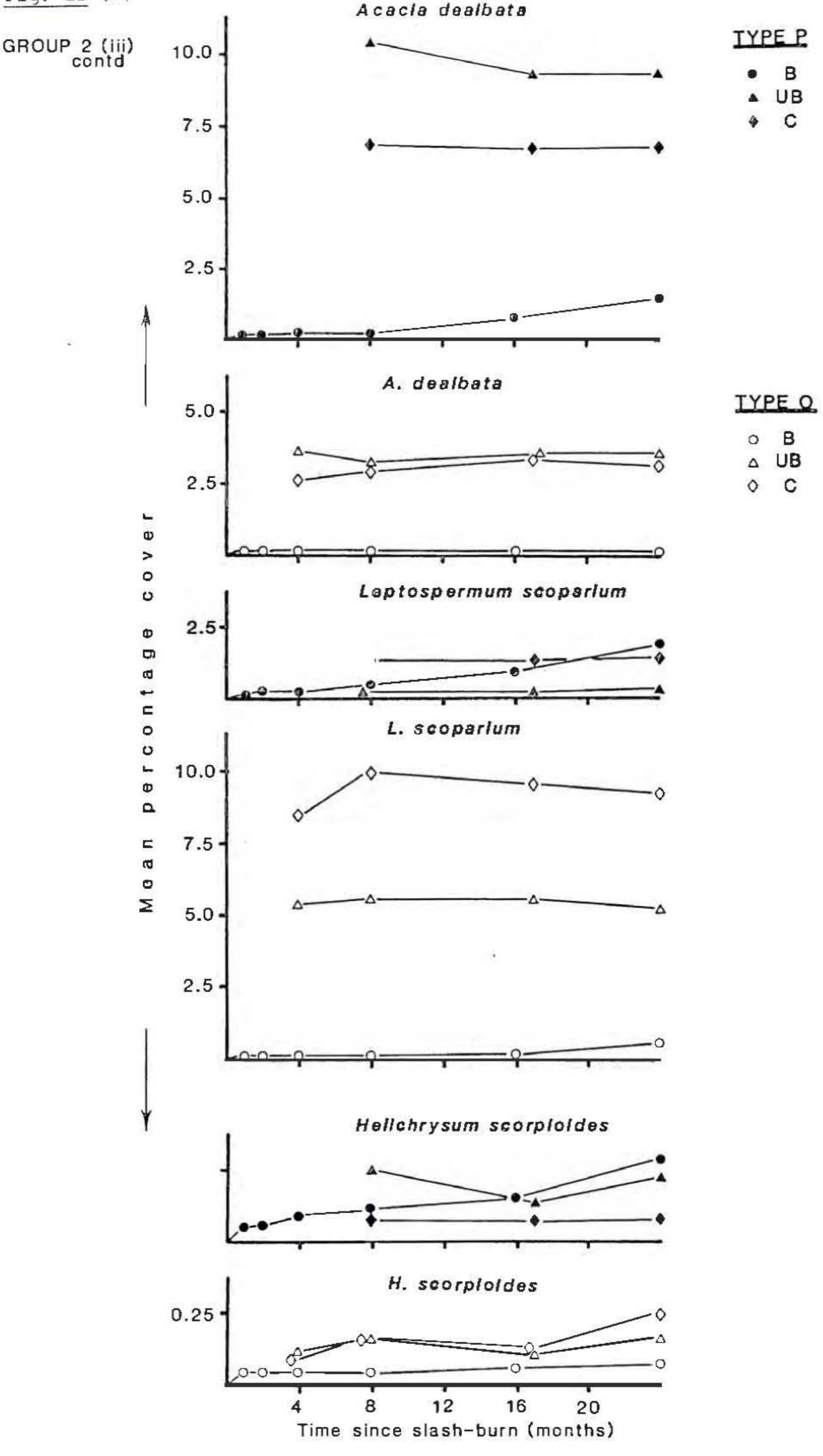

GROUP 2 (i)
Poa spp
TYPE P
B
UB
C
Poa spp
TYPE O
B
UB
C
(ii)
Hydrocotyle javanica
H. javanica
(iii)
Deyeuxia spp
Deyeuxia spp
Mean percentage cover
25
20
15
10
5
0.25
0.75
0.5
4
8
12
16
20
Time since slash-burn (months)

Fig. 13 (b) contd.



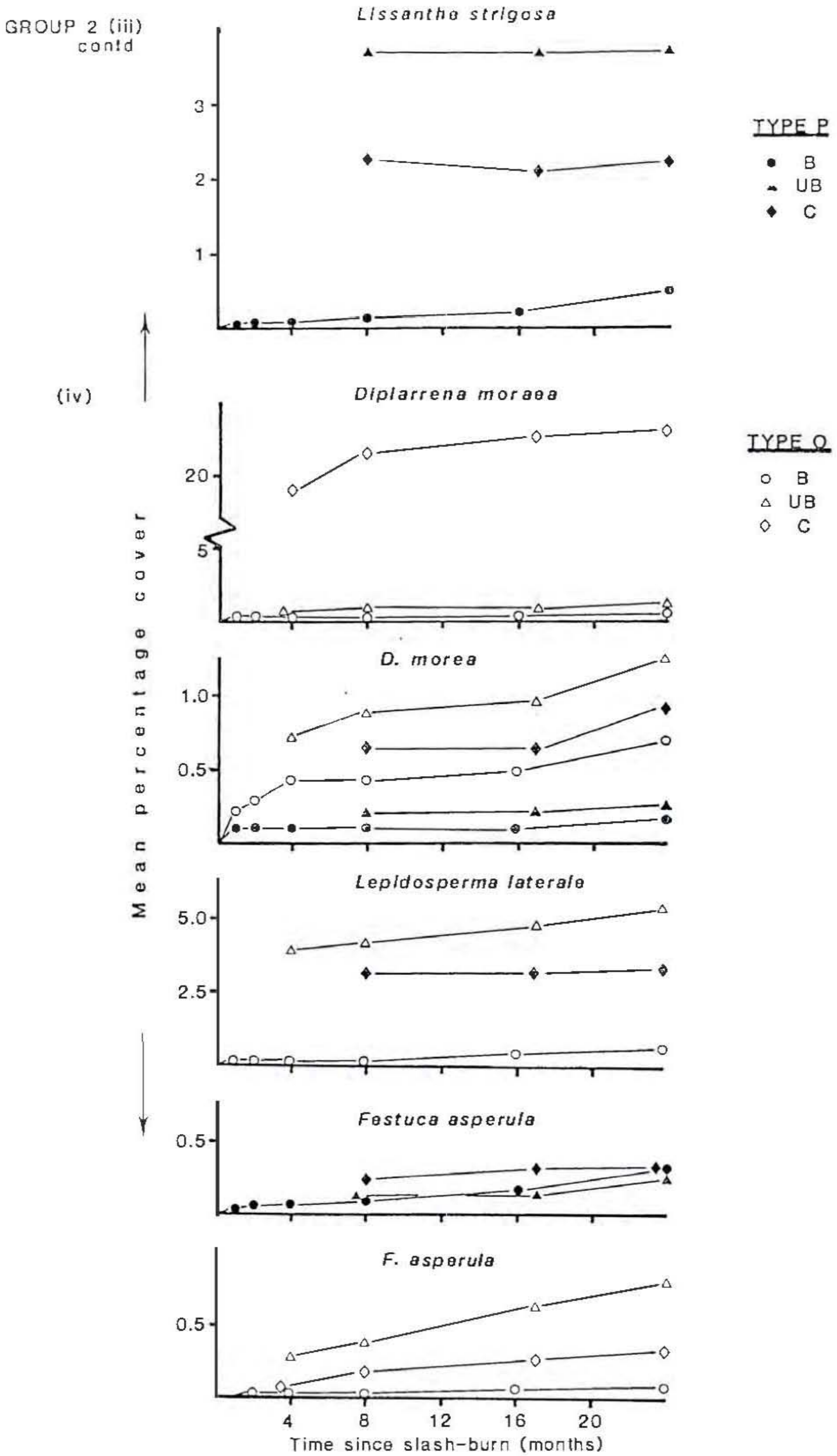
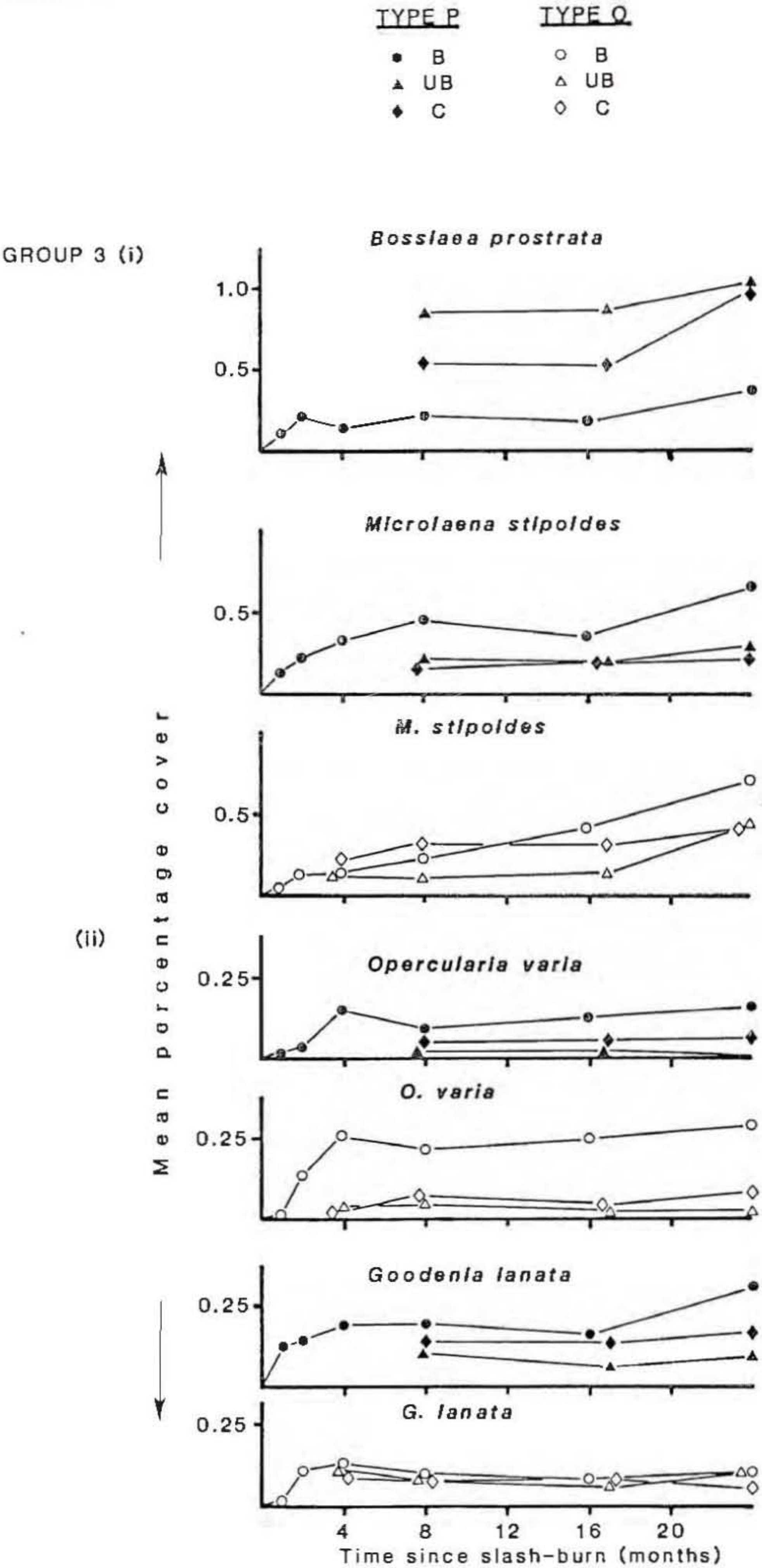

GROUP 2 (iii)
contd
(iv)
Lissantha strigosa
Diplarrena moraea
D. morea
Lepidosperma laterale
Festuca asperula
F. asperula
TYPE P
B
UB
C
TYPE Q
B
UB
C
Mean percentage cover
Time since slash-burn (months)
4
8
12
16
20
0.5
1.0
2.5
5.0
5
20
1
2
3

Fig. 13 (b) contd.



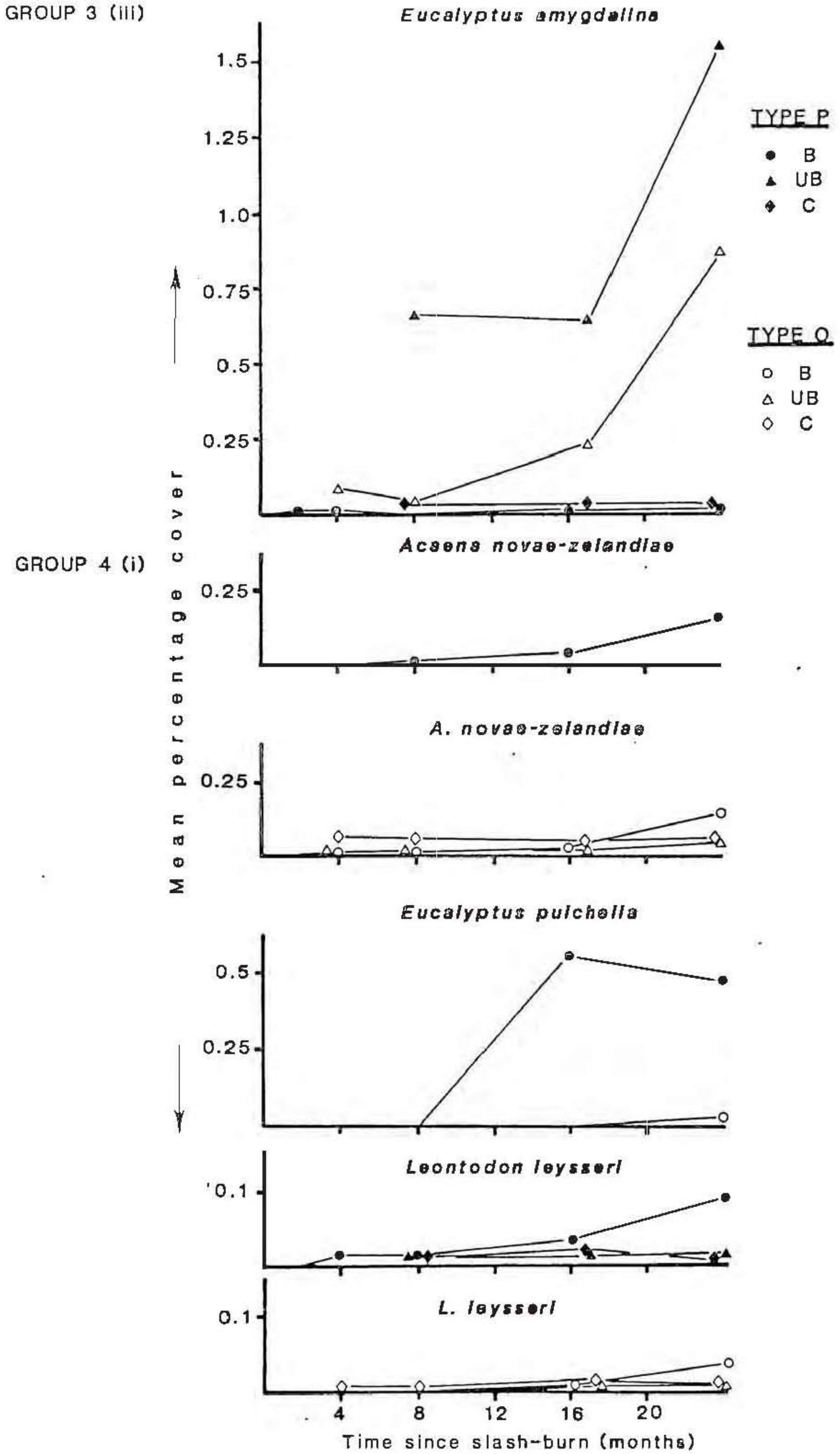

GROUP 3 (iii)
Eucalyptus amygdalina
1.5
1.25
1.0
0.75
0.5
0.25
TYPE P
B
UB
C
TYPE Q
B
UB
C
GROUP 4 (i)
Acaena novae-zelandiae
0.25
A. novae-zelandiae
0.25
Mean percentage cover
Eucalyptus pulchella
0.5
0.25
Leontodon leysseri
0.1
L. leysseri
0.1
4
8
12
16
20
Time since slash-burn (months)

Fig. 13 (b) contd.

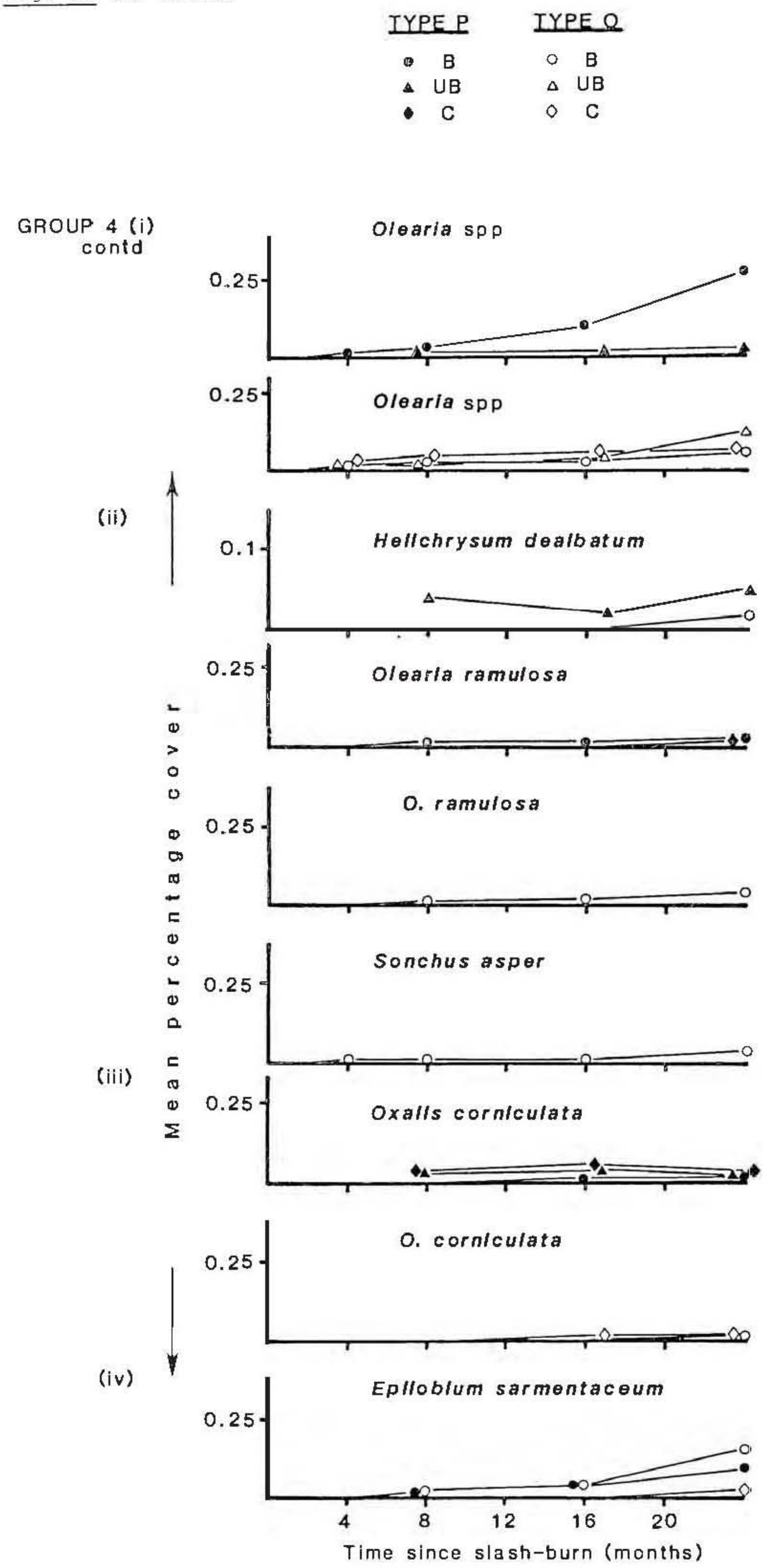


Fig. 13 (b) contd.

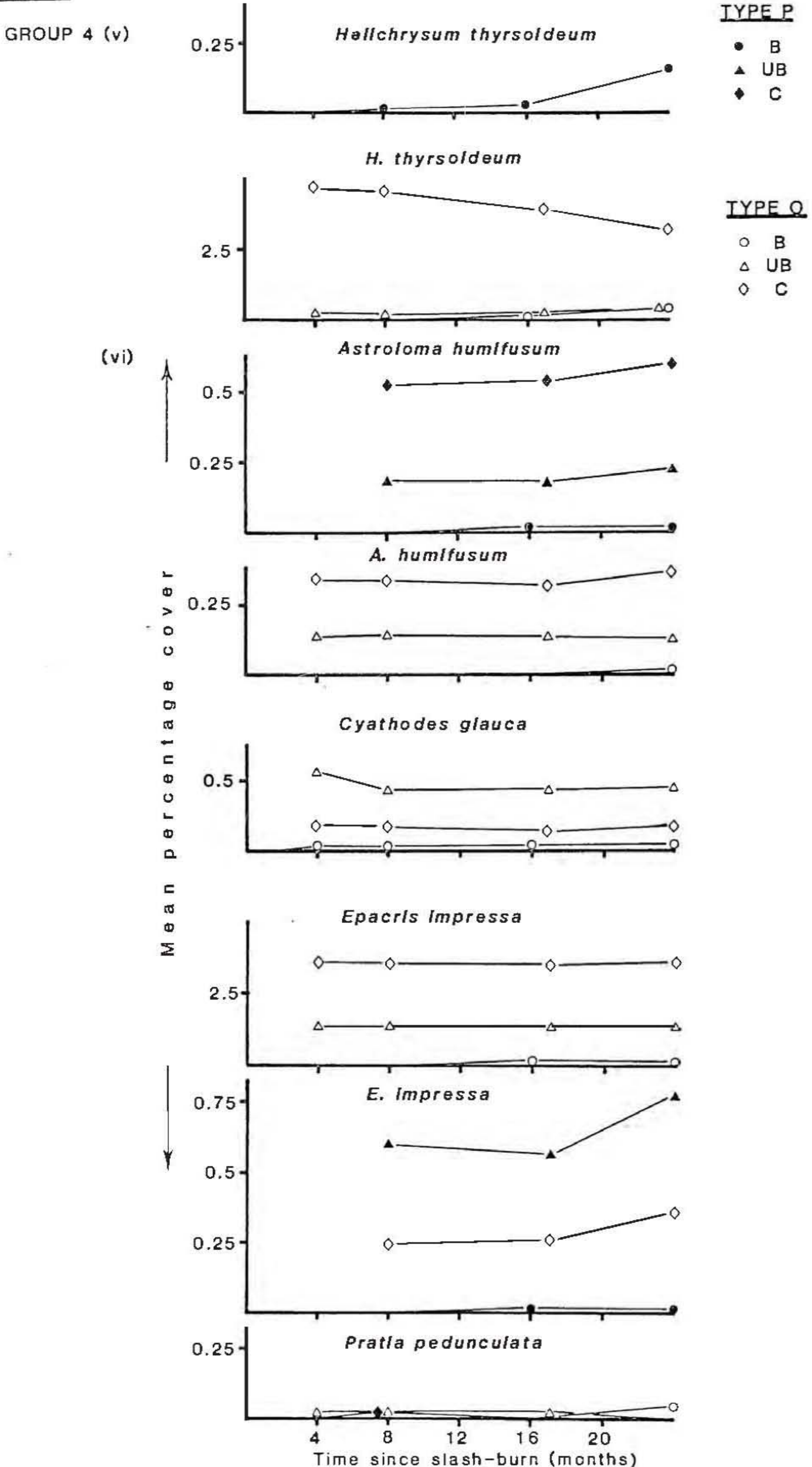
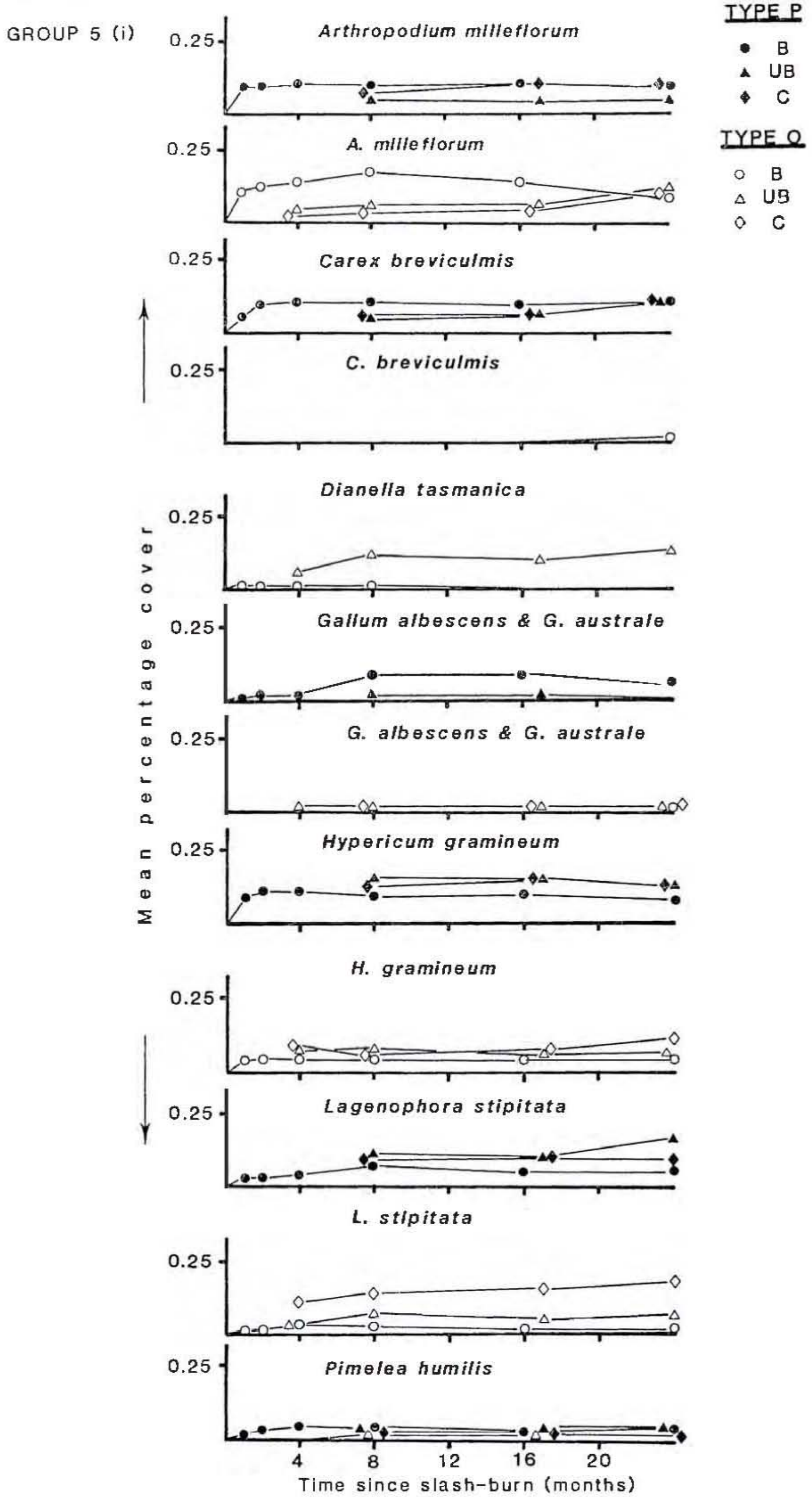


Fig. 13 (b) contd.



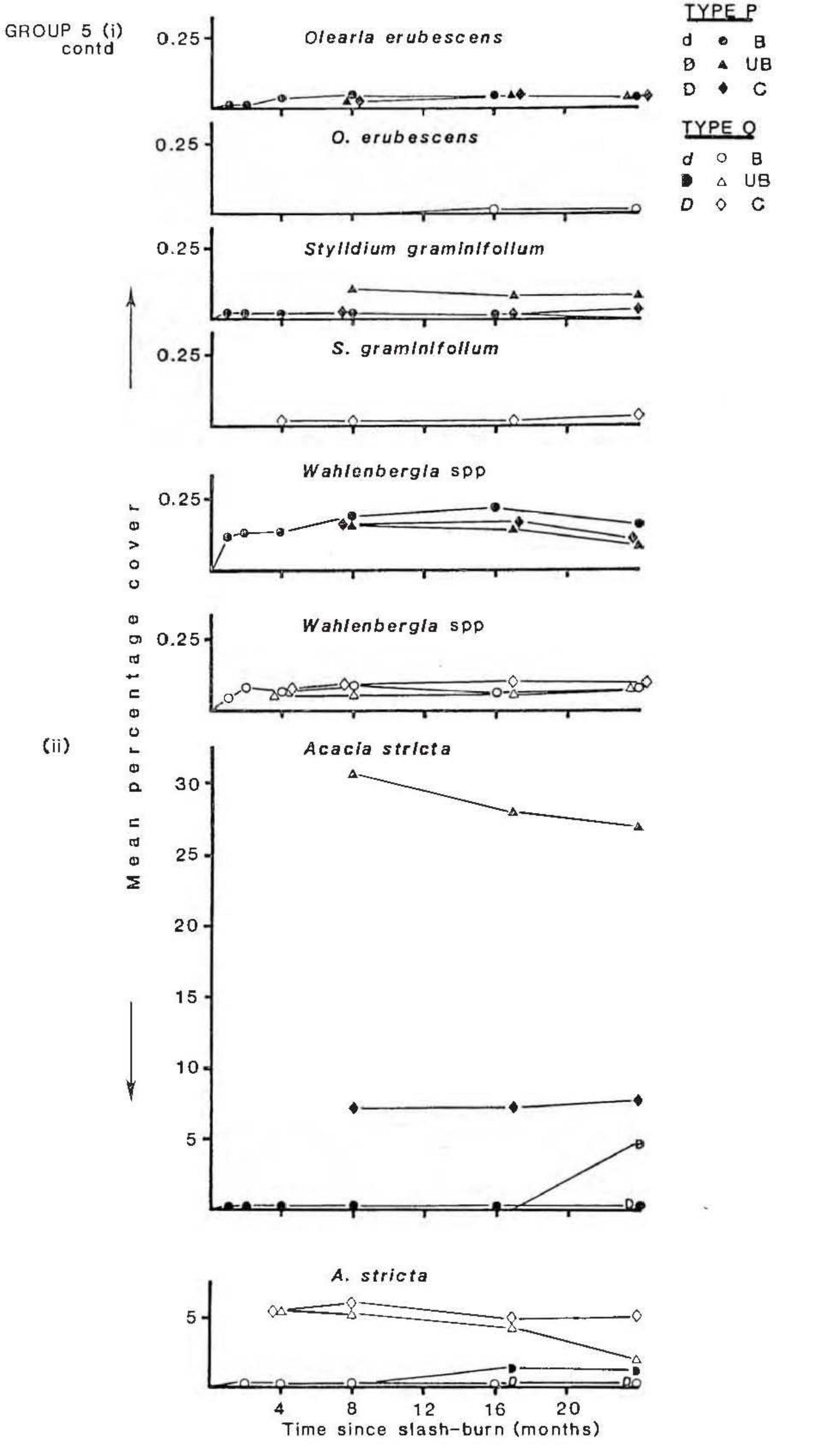

GROUP 5 (i)
contd
TYPE P
d B
D UB
D C
TYPE Q
d B
UB
D C
Olearia erubescens
O. erubescens
Stylidium graminifolium
S. graminifolium
Wahlenbergia spp
Wahlenbergia spp
(ii)
Acacia stricta
A. stricta
Mean percentage cover
0.25
30
25
20
15
10
5
4
8
12
16
20
Time since slash-burn (months)

Fig. 13 (b) contd.

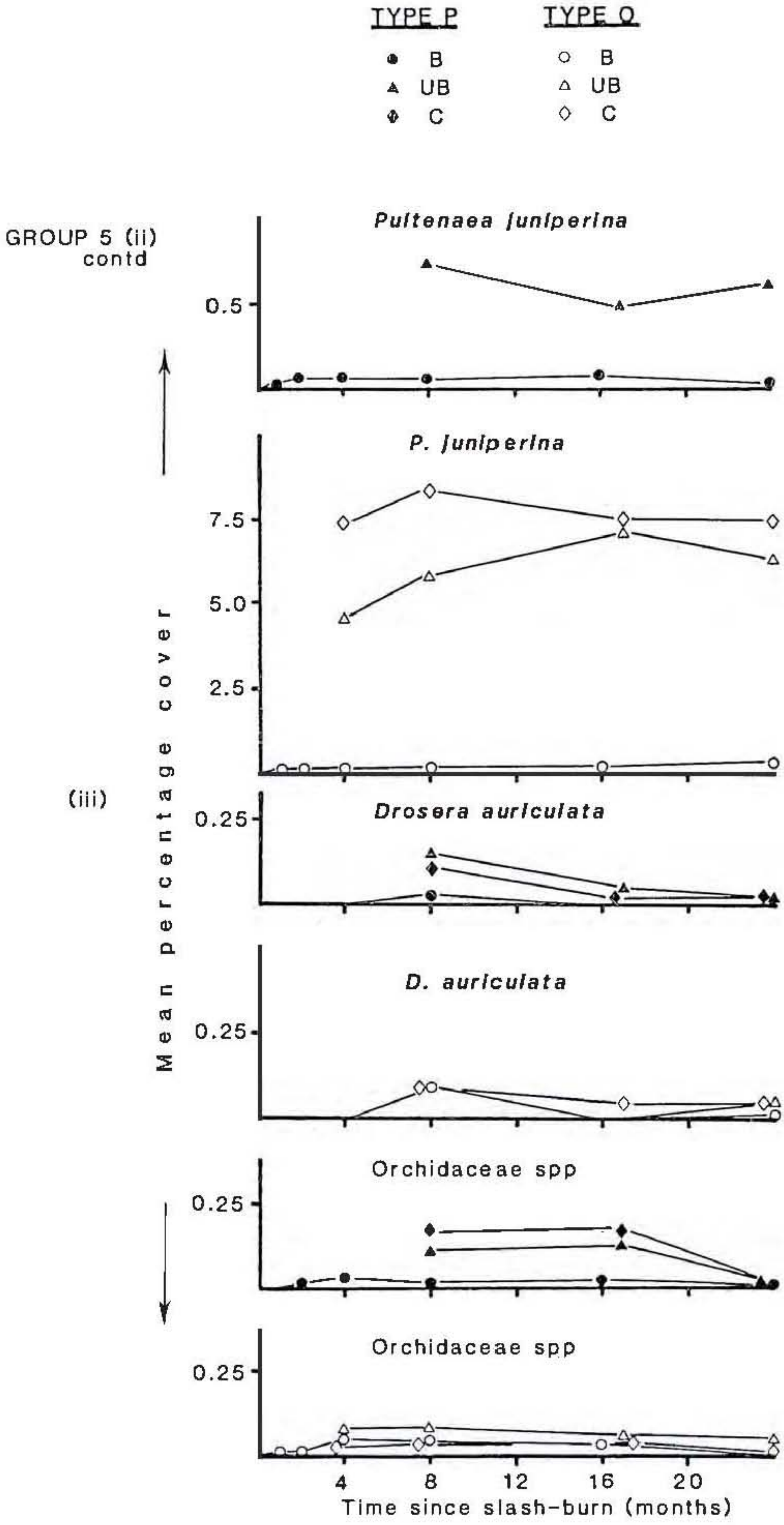
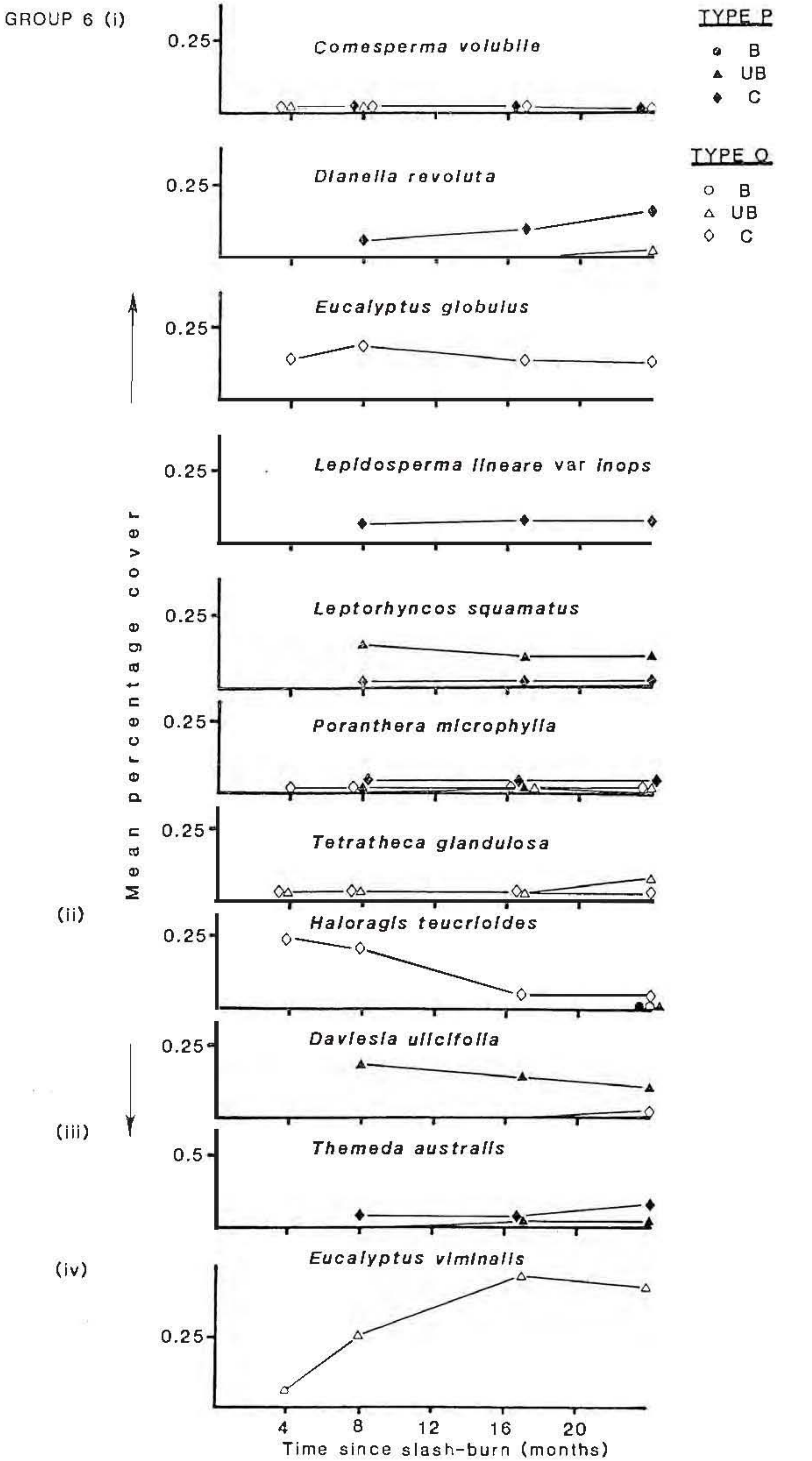


Fig. 13 (b) contd.



Group 6 contd.

(iv) This species was not present before or after the slash-burn on treatment B but showed rapid growth on treatment UB.

T Eucalyptus viminalis -

A list of species, including those of rare occurrence, recorded in the permanent quadrats in each treatment, control and vegetation type is given in Appendix 2. Treatment B records are given for before and after the slash-burn. Records for treatment UB and the control C, which were collected during the original floristic survey and the subsequent vegetation mapping are also included.

2.5.2.3 Species diversity and species richness

Values for N_2 through time in types O and P on both treatments, and controls are shown in Fig. 14a. High values occur immediately following the slash-burn in both vegetation types. Treatment B values show marked fluctuation over the 24 months of the study.

Fluctuations in N_2 on treatment B can be attributed to pulses in growth of certain species. Point 1 in Fig. 14a depicts the effect on N_2 of the rapid growth of Gahnia grandis. At point 2, dominance by G. grandis is gradually reduced by the increasing cover of Lomandra longifolia, Pteridium esculentum and Senecio minimus. Similarly, in type P, point 3 indicates the increasing dominance of Lomandra longifolia, and point 4 signifies the effect on N_2 of rapid growth of this species. Beyond point 4, the degree of polydominance rises due to the increasing cover of Pteridium esculentum, Schoenus apogon and Senecio minimus. The species contributing most to fluctuations in N_2 on treatment B are all group 1 species (section 2.5.2.2).

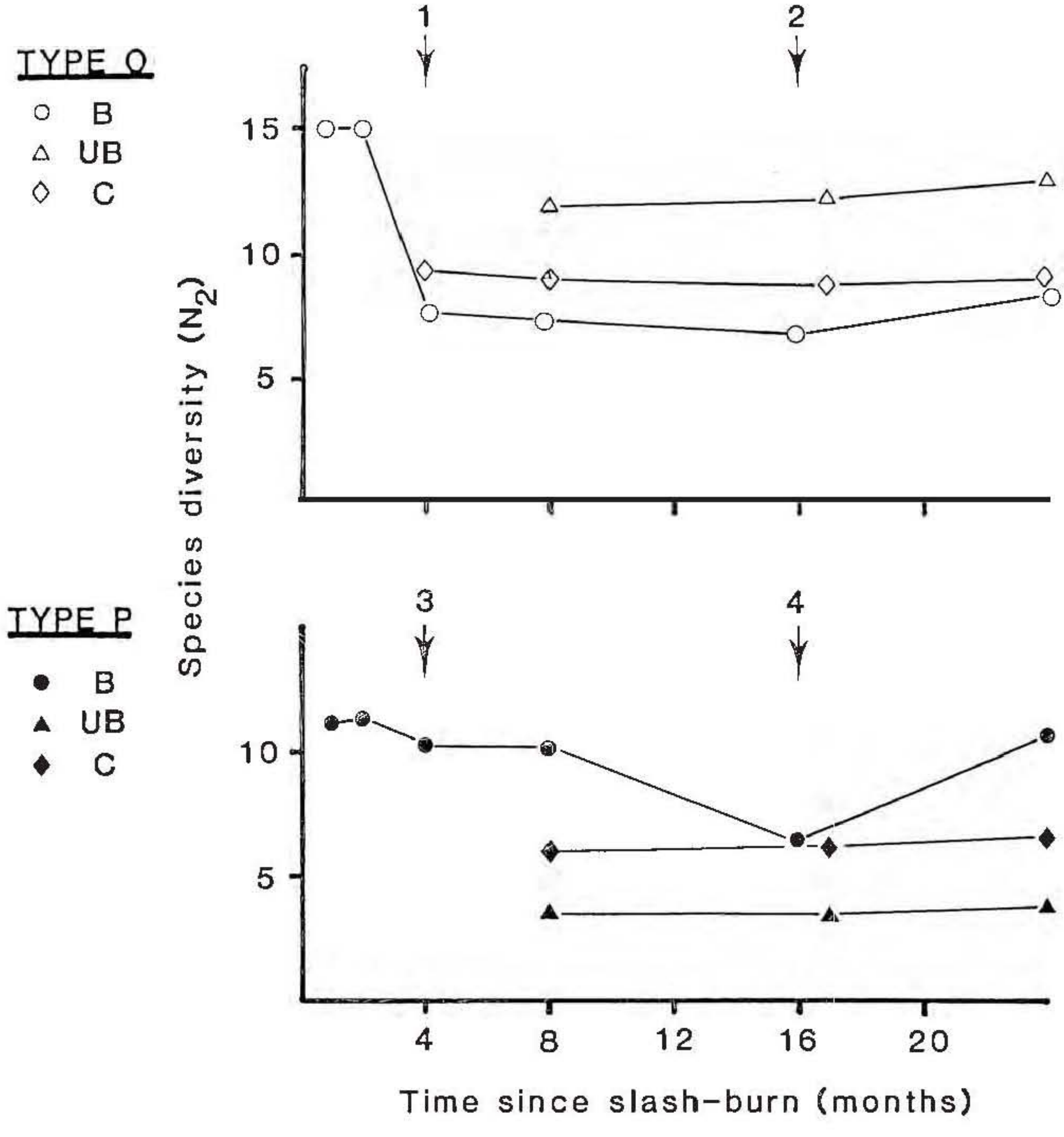


Fig. 14 : The species diversity through time on the permanent plots in each vegetation type (P and O), treatment (B and UB) and control (C) at MM14.

(a) The diversity index, N_2.

The arrows mark positions where the growth of certain species greatly influence the diversity index (see section 2.5.2.3).

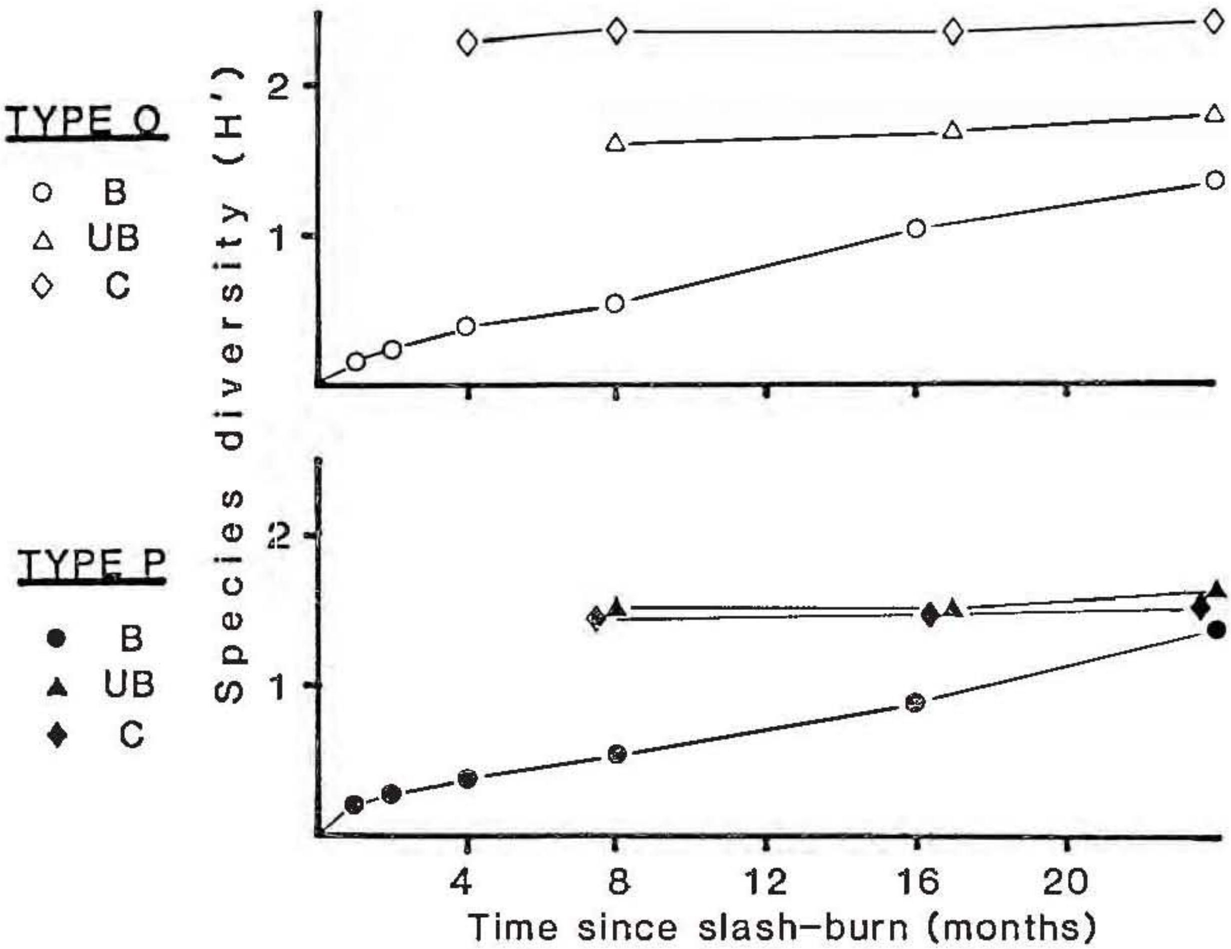


Fig. 14 cont'd. (b) The diversity index, H'.

Values of N_2 calculated for treatment UB, and the control C remain approximately stable over the period studied. Type P, treatment UB, has relatively low results when compared to treatment B and the control C, due to cover dominance by Acacia dealbata and A. stricta.

The slight increases in N_2 which were registered in both vegetation types on treatment UB and the control C, 16-24 months after the time of the slash-burn may be partly attributable to fluctuations in cover shown by Acacia stricta and Pultenaea juniperina (group 5: section 2.5.2.2).

The index, H', has very low values one month after the slash-burn in both vegetation types (Fig. 14b). Values increased rapidly, however, during the 24 months of the study, attaining equivalent levels to treatment UB and the control C, in the case of type P. There was no indication that values of H' had begun to stabilize by levelling off on treatment B, 24 months post-burn.

H' results for type O, treatment UB were lower than for the control C. Plant cover was less on treatment UB due to the presence of slash (Table 5). Values for H' remained approximately stable through time on treatment UB and the control C, in both types P and O.

Species richness (number of species present) through time for each vegetation type, treatment and control is shown in Fig. 15. The number of species increased from 39, 1 month post-burn, to 56 after 24 months in type P, treatment B. Forty-four species were recorded prior to burning. In type O, species richness rose from 30, 1 month post-burn, to 58 after 24 months. Thirty-eight species were recorded before the burn. The number of species was still increasing in both vegetation types 24 months after the slash-burn.

Approximately 75% and 79% of the species recorded before the slash-burn were present within 2 months of burning in types P and O

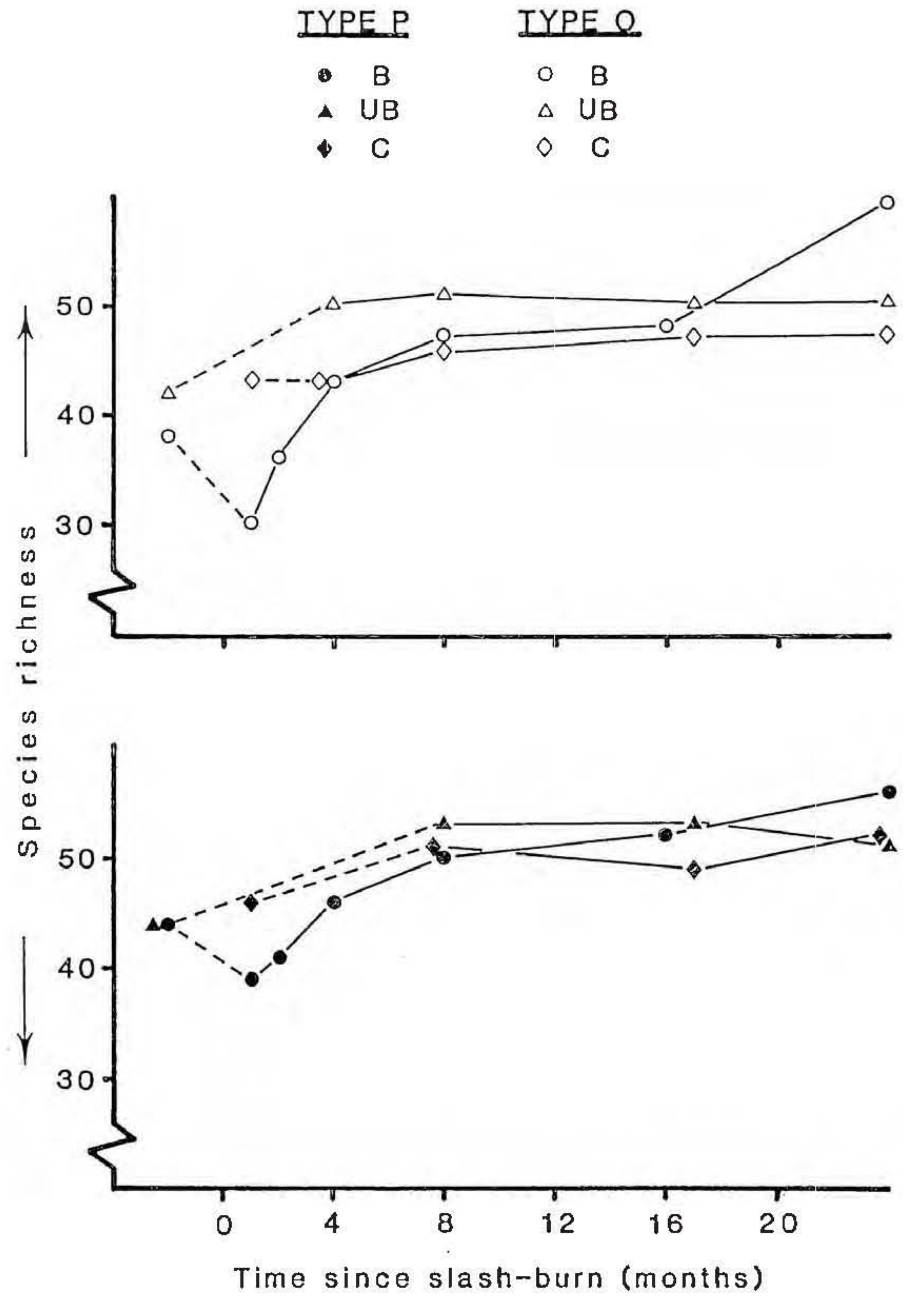


Fig. 15 : Species richness through time on the permanent plots in each vegetation type (P and O), treatment (B and UB) and control (C) at MM14.

Dashed lines link the species richness of the permanent plots recorded during the floristic survey, to the species richness recorded during the course of the detailed vegetation mapping.

respectively. The proportions increased to 82% for type P, and 87% for type O, after 24 months. Species absent from plots for the 24 months following burning, but present beforehand, were; in type P, Brachycome scapiformis, Caladenia catenata, Craspedia glauca, Cyathodes glauca, Lepidosperma laterale, and in type O, Acacia genistifolia, Senecio spp., Sonchus oleraceus and Themeda australis. However, it is possible that these species occurred in the central corridor of the quadrats which was omitted from the detailed recording (section 2.3.4) but were eliminated due to trampling effects.

Species richness increased in both vegetation types under treatment UB. Establishment of additional species was greatest during the first 8 months following the time of the slash-burn. Species number was affected by intermittent records of ephemeral species such as Drosera auriculata and various species of Orchidaceae.

Certain species established successfully on both treatments B and UB but were not recorded prior to the time of the slash-burn, for example Acaena novae-zelandiae, Hydrocotyle javanica and Opercularia varia. The majority of the fluctuation in species richness which was recorded on the control sites, was due to seasonal presence and absence of particular species.

2.5.2.4 Post-fire density and demographic change

Figures for establishment, disappearance and density per $100m^2$ for individuals of selected species are shown in Table 6.

(1) Type P (Table 6A)

Herb species have the greatest turnover of individuals as well as the highest density throughout the study period. Plantago varia had the greatest density 1 month after the slash-burn. Subsequent records of P. varia show that the establishment of individuals is in excess of

A similar reversal is also shown by Hypericum gramineum after 4 months, Arthropodium milleflorum, Galium australe and Goodenia lanata after 8 months; Haloragis tetragyna and Lagenophora stipitata after 16 months; and Wahlenbergia spp. after 24 months. Consistent establishment of individuals in excess of disappearance is shown by Galium albescens, Helichrysum scorpioides, H. thyrsoideum, Hypochaeris radicata, Leontodon leysseri, Lissanthe strigosa and Senecio minimus. Galium australe had a greater density than G. albescens during the course of the study period.

Species in which all individuals persisted throughout were Epacris impressa, Epilobium sarmentaceum, Eucalyptus amygdalina, E. pulchella, and Oxalis corniculata. Stylidium graminifolium disappeared completely between 4 and 8 months after the time of the slash-burn.

Shrub and tree species showed considerably less turnover of individuals than did other lifeforms.

(2) Type O (Table 6B)

Arthropodium milleflorum has the greatest number of individuals present 1 month after the slash-burn, but was exceeded in density by Haloragis tetragyna after 2 months. Disappearance exceeds establishment in the latter species from 4-16 months. The same is true for Arthropodium milleflorum from 16-24 months, Hypericum gramineum and Pultenaea juniperina from 8-24 months, and Wahlenbergia spp. from 8-16 months.

In general, density of herb species is less in type O than in type P. Shrub and tree apecies vary between the two types. Pultenaea juniperina turnover and density is greater in type O than in type P, while the reverse is true of Olearia spp., O. erubescens, and Helichrysum thyrsoideum. Acacia stricta and Olearia ramulosa have

TABLE 6: Temporal change after the slash-burn in establishment, disappearance and density, per $100m^2$, of species individuals on the treatment B permanent quadrats. (A) P = *Eucalyptus pulchella* dominated. (B) O = *E. obliqua* dominated. Dis = Number of individuals/$100m^2$ no longer present from previous recording time; New = number of individuals/$100m^2$ newly established since previous recording time; D = number of individuals present at a particular recording time. Figures are given to the nearest integer value.

(A)

Life-form	Treatment B:	TIME SINCE SLASH-BURN (MONTHS)																	
	Type P	1			2			4			8			16			24		
		Number of individuals/$100m^2$																	
	Species	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D
S	*Acacia stricta*	-	7	7	-	2	9	-	-	9	5	4	9	5	2	7	2	5	9
Gr	*Arthropodium milleflorum*	-	140	140	11	38	167	20	31	178	36	22	165	22	18	160	56	-	105
Gr	*Carex breviculmis*	-	65	65	18	9	56	-	11	67	9	27	85	31	20	74	22	14	65
H	*Cirsium vulgare*	-	9	9	-	-	9	-	7	16	-	7	22	7	16	31	9	-	22
S	*Epacris impressa*	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	2	4
H	*Epilobium sarmentaceum*	-	-	-	-	-	-	-	-	-	-	-	8	-	11	16	-	9	25
T	*Eucalyptus amygdalina*	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	2
T	*E. obliqua*	-	-	-	-	2	2	2	2	2	-	2	4	-	4	9	-	-	9
T	*E. pulchella*	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	2
H	*Galium albescens*	-	-	-	-	2	2	-	2	4	-	14	18	16	29	31	29	-	2
H	*G. australe*	-	4	4	-	74	78	51	58	85	45	38	78	47	25	56	42	26	40
H	*Goodenia lanata*	-	154	154	22	64	196	25	94	265	80	67	251	67	84	269	100	91	260
H	*Haloragis tetragyna*	-	220	220	29	514	705	211	236	729	236	431	925	407	394	911	305	362	969
H	*Helichrysum scorpioides*	-	40	40	4	31	67	9	22	80	11	18	87	9	38	116	18	34	131
S	*H. thyrsoideum*	-	-	-	-	-	-	-	-	-	-	2	2	-	18	20	2	11	34
H	*Hypericum gramineum*	-	214	214	47	78	245	82	42	205	67	16	154	78	38	114	69	42	87
H	*Hypochaeris radicata*	-	2	2	-	2	4	-	7	11	-	11	22	7	18	34	7	58	85
H	*Lagenophora stipitata*	-	29	29	5	27	51	16	18	54	16	31	68	36	14	47	27	14	34
H	*Leontodon leysseri*	-	-	-	-	-	-	-	4	4	-	-	4	-	4	9	2	47	54
S	*Lissanthe strigosa*	-	2	2	-	56	58	9	56	105	36	189	258	76	362	545	116	234	662
S	*Olearia erubescens*	-	4	4	-	7	11	-	-	11	2	-	9	-	-	9	-	2	11
S	*Olearia* spp.	-	-	-	-	-	-	-	2	2	-	9	11	5	31	38	5	2	36
S	*O. ramulosa*	-	-	-	-	-	-	-	-	-	-	2	2	-	2	4	4	4	4
H	*Oxalis corniculata*	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	2	4
S	*Pimelea humilis*	-	4	4	-	49	54	14	14	54	25	2	31	11	14	34	9	7	31
H	*Plantago varia*	-	349	349	27	556	878	56	274	1096	85	165	1176	198	91	1069	96	116	1089
S	*Pultenaea juniperina*	-	14	14	-	18	31	11	2	22	18	4	9	4	20	25	11	11	25
H	*Senecio minimus*	-	-	-	-	2	2	-	11	14	2	40	51	7	25	69	14	20	76
H	*Stylidium graminifolium*	-	14	14	-	-	14	-	-	14	14	-	-	-	-	-	-	-	-
H	*Wahlenbergia* spp.	-	149	149	38	91	202	65	82	220	98	164	287	151	158	294	182	76	187

TABLE 6 cont'd.
(B)

Life-form	Treatment B:	TIME SINCE SLASH-BURN (MONTHS)																	
	Type O	1			2			4			8			16			24		
		Number of individuals/100m^2																	
	Species	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D	Dis	New	D
S	Acacia stricta	-	-	-	-	2	2	-	-	2	-	5	7	2	5	9	2	2	9
Gr	Arthropodium milleflorum	-	120	120	14	76	182	47	38	174	20	36	189	69	22	142	58	7	91
S	Astroloma humifusum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Gr	Carex breviculmis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
H	Cirsium vulgare	-	14	14	9	4	9	-	9	18	-	7	25	2	100	122	54	65	134
S	Cyathodes glauca	-	-	-	-	2	2	-	-	2	-	-	2	-	7	9	2	2	9
Gr	Dianella tasmanica	-	2	2	2	9	9	7	-	2	-	2	4	4	-	-	-	-	-
S	Epacris impressa	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7	-	25	31
H	Epilobium sarmentaceum	-	-	-	-	-	-	-	-	-	-	7	7	-	7	14	2	36	47
T	Eucalyptus obliqua	-	-	-	-	-	-	-	11	11	2	16	25	11	29	42	7	5	40
H	Galium albescens + G. australe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4
H	Geranium potentilloides	-	-	-	-	2	2	-	5	7	-	5	11	2	9	18	5	27	40
H	Gnaphalium collinum	-	20	20	-	20	40	16	36	60	-	125	185	62	46	169	71	102	200
H	Goodenia lanata	-	34	34	9	69	94	14	71	151	53	54	151	91	20	80	36	42	87
H	Haloragis tetragyna	-	71	71	7	515	580	145	174	609	211	116	514	254	105	365	118	147	394
H	H. teucrioides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4
H	Helichrysum dealbatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9
H	H. scorpioides	-	31	31	-	9	40	5	7	42	7	7	42	11	16	47	16	9	40
S	H. thyrsoideum	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	-	-	4
H	Hypericum gramineum	-	60	60	14	34	80	22	16	74	31	9	51	25	4	31	25	9	16
H	Hypochaeris radicata	-	2	2	-	-	2	-	20	22	-	9	31	7	29	54	9	29	74
H	Lagenophora stipitata	-	11	11	2	2	11	2	20	29	7	7	29	16	-	14	-	20	34
H	Leontodon leysseri	-	-	-	-	-	-	-	-	-	-	-	-	4	4	-	-	4	9
S	Olearia erubescens	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	2
S	Olearia spp.	-	-	-	-	-	-	-	4	4	-	4	9	2	2	9	2	7	14
S	O. ramulosa	-	-	-	-	-	-	-	-	-	-	2	2	-	7	9	2	9	16
H	Pratia pedunculata	-	-	-	-	9	9	2	11	18	2	4	20	9	14	25	11	16	29
S	Pultenaea juniperina	-	7	7	5	118	120	62	87	145	82	47	109	58	40	91	45	40	85
H	Senecio minimus	-	-	-	-	7	7	-	14	20	-	25	45	4	27	69	25	34	78
H	Sonchus asper	-	-	-	-	-	-	-	-	-	-	2	2	2	16	16	2	11	25
H	Wahlenbergia spp.	-	80	80	9	60	131	51	62	142	49	34	127	107	20	40	36	42	47

similar patterns of establishment and mortality in the two vegetation types.

Those species with the highest densities do not necessarily show accelerated growth 8-24 months after the slash-burn (group 1: section 2.5.2.2). For example, Arthropodium milleflorum, Carex breviculmis, Hypericum gramineum and Wahlenbergia spp. show little growth or a gradual decline in cover (group 5: section 2.5.2.2). Much of the variation shown by group 5 species is attributable to preferential browsing (see Chapter 3).

2.5.2.5 Spatial distribution of species and lifeforms on treatment B

Cover values for certain dominant species, together with composite data for other species in the individual subquadrats of the permanent plots on treatment B, are presented in Fig. 16. Fire intensities for each permanent plot are illustrated diagrammatically on the transparent overlays of Fig. 16 (l), (m) (sleeve inside back cover). Intensity was divided into six broad categories. The type O permanent quadrats generally experienced higher fire intensities than did those in type P, where the fire pattern was patchy and low intensity classes predominated.

(1) Type O (Fig. 16 (a) - (f))

Gahnia grandis, Pteridium esculentum and Senecio minimus achieve significantly higher cover (M-W: $p = 0.05$) in the subquadrats which were burnt intensely. Conversely, the composite group of grasses, and Schoenus apogon favour areas of low intensity burn. Lomatia tinctoria and Eucalyptus obliqua are not significantly different between areas which had been burnt by fires of high and low intensity.

Herbs (excluding Senecio minimus) and shrubs (excluding Lomatia tinctoria) are initially concentrated on the intensely burnt subquadrats. However, 24 months after the slash-burn, there is no significant difference between high and low fire intensity classes.

The cover of Diplarrena moraea and the composite group of graminoids (dominated by Arthropodium milleflorum) are similar between areas burnt by high and low intensity fire. The distribution of these species in the permanent plots becomes more restricted through time (see Chapter 3).

(2) Type P (Fig. 16 (g) - (k))

Schoenus apogon and the composite groups of grasses, herbs and shrubs have significantly greater cover ($p = 0.01$) in areas of low intensity burn. Lomatia tinctoria established successfully ($p = 0.02$) in the more intensely burnt subquadrats of Plot 2 than in the areas of lighter burn. Pteridium esculentum showed no significant difference in cover ($p = 0.05$) between areas burnt by high and low intensity fire on Plot 2.

Senecio minimus established in areas of high and low intensity burn but growth was less rapid than in type O, Plots 1 and 2 (see group 1: section 2.5.2.2). The distribution of Lomandra longifolia also appeared to be unaffected by fire intensity within the permanent plots.

The cover of Eucalyptus spp. (Plot 1: E. pulchella, E. amygdalina; Plot 2: E. obliqua) is less than in type O. The distribution and cover of eucalypts in type P subquadrats is not significantly different between areas burnt with fire of high or low fire intensity. The large cover values of E. pulchella on Plot 1 are due to coppice growth from a stump adjacent to the quadrat. After an initial growth flush, sprouting died back resulting in reduced measurement at 24 months.

Fig. 16

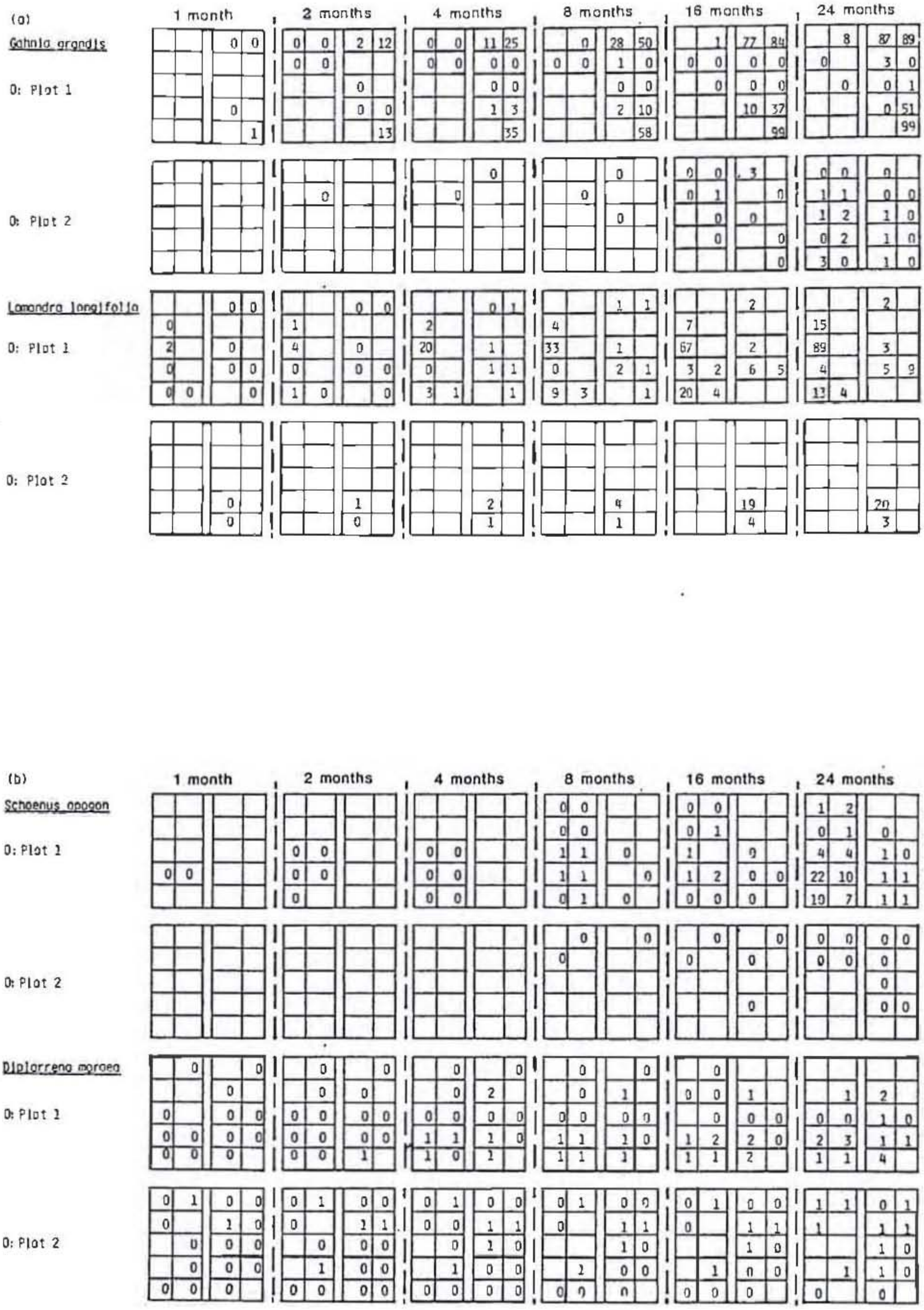
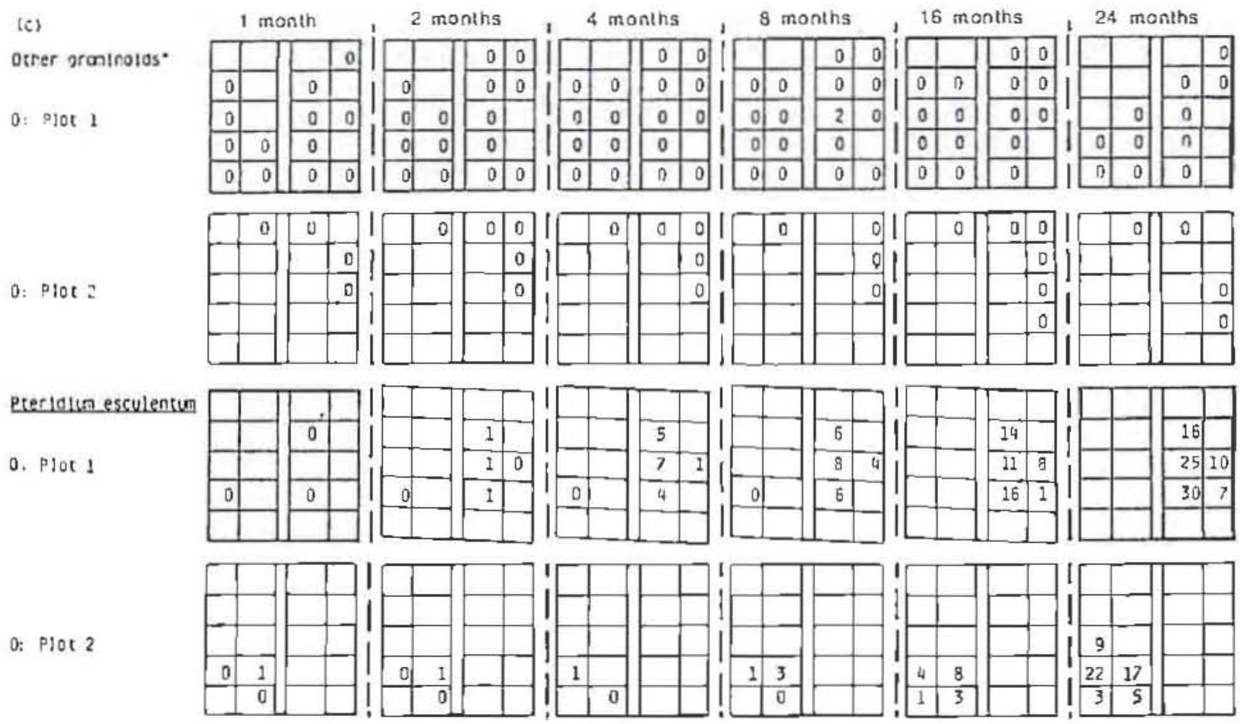

(a)
1 month
2 months
4 months
8 months
16 months
24 months
Gahnia grandis
0: Plot 1
0: Plot 2
Lomandra longifolia
0: Plot 1
0: Plot 2
(b)
1 month
2 months
4 months
8 months
16 months
24 months
Schoenus apogon
0: Plot 1
0: Plot 2
Diplarrena moraea
0: Plot 1
0: Plot 2

Fig. 16 contd.



*mainly Arthropodium milleflorum

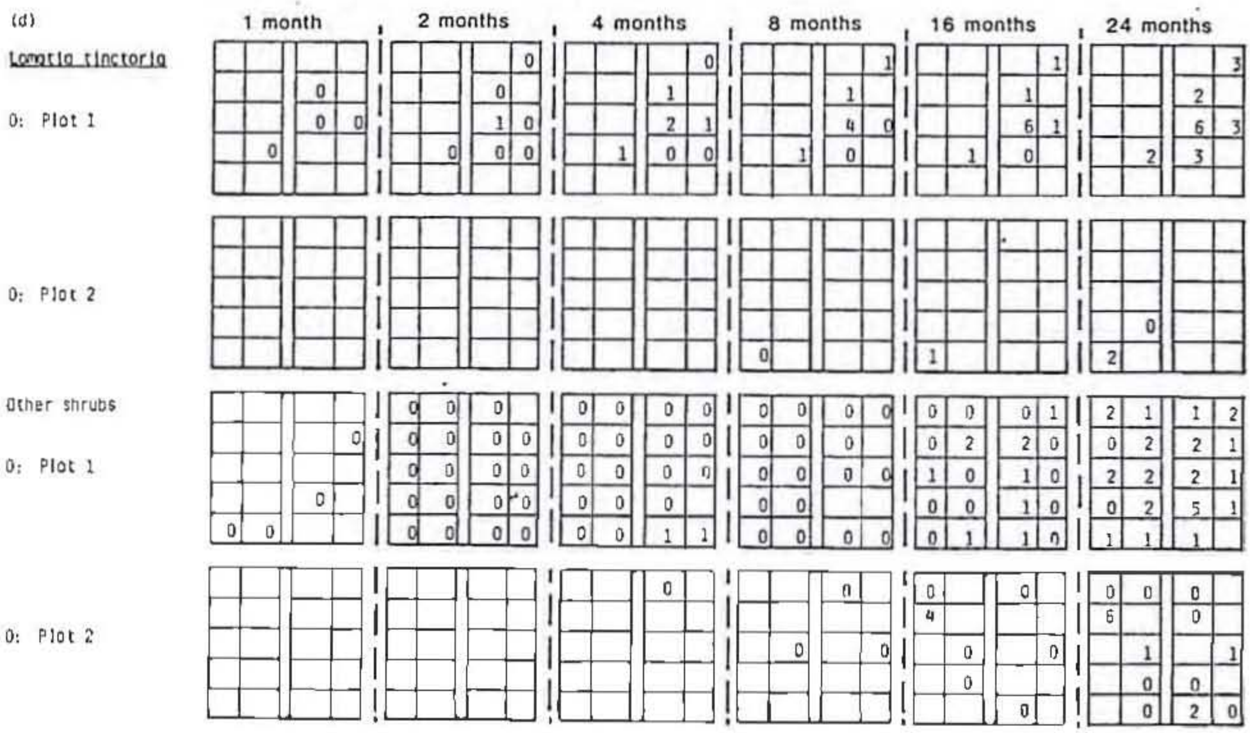
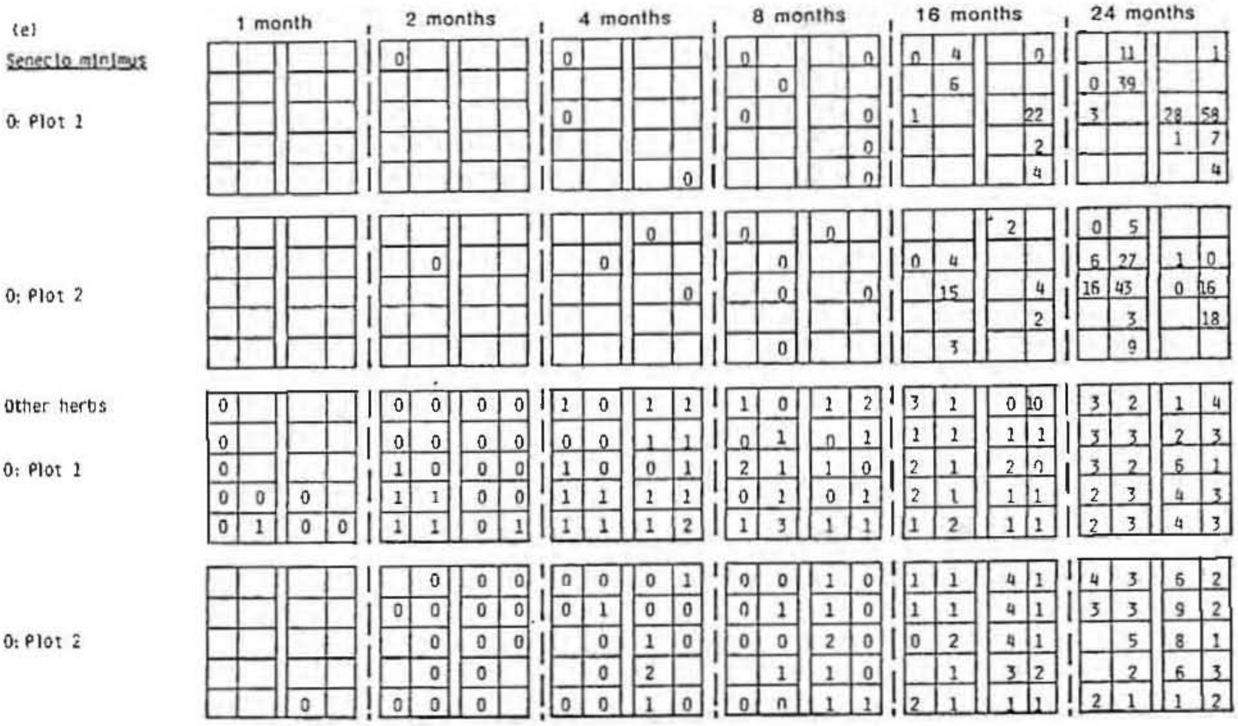


Fig. 16 contd.


(e)
Senecio minimus
0: Plot 1
0: Plot 2
Other herbs
0: Plot 1
0: Plot 2
1 month
2 months
4 months
8 months
16 months
24 months

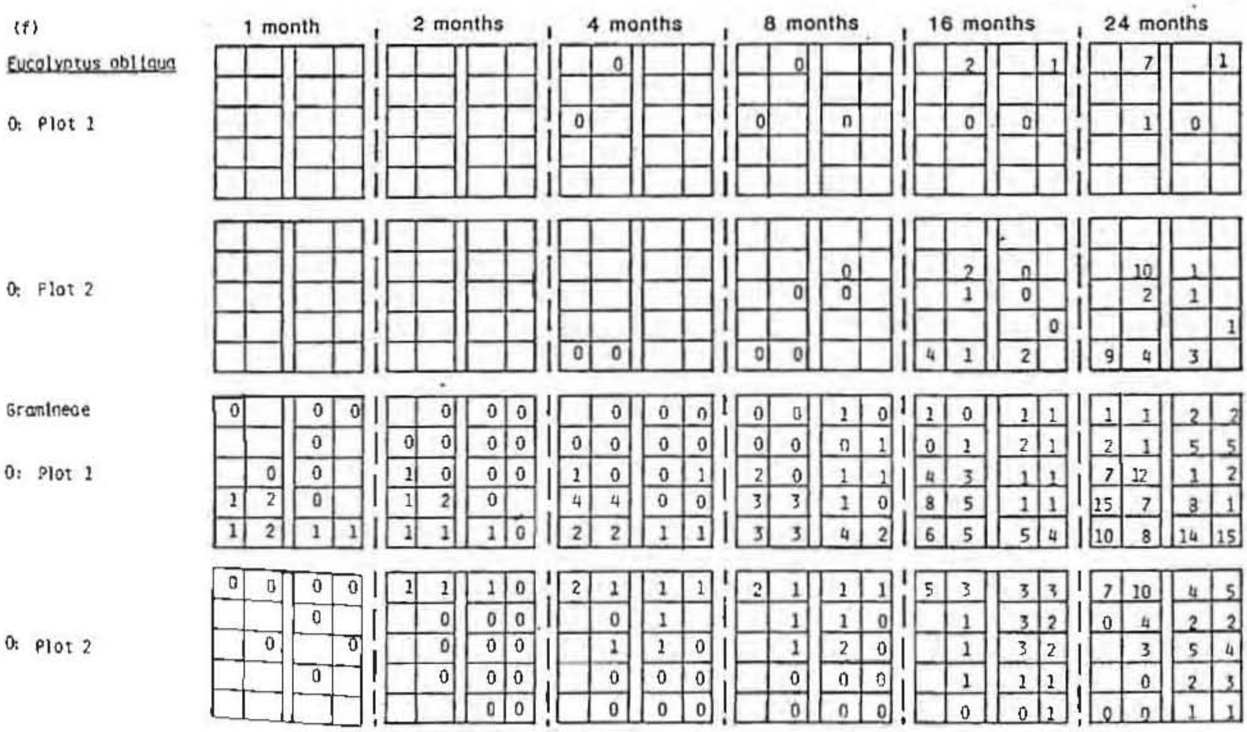
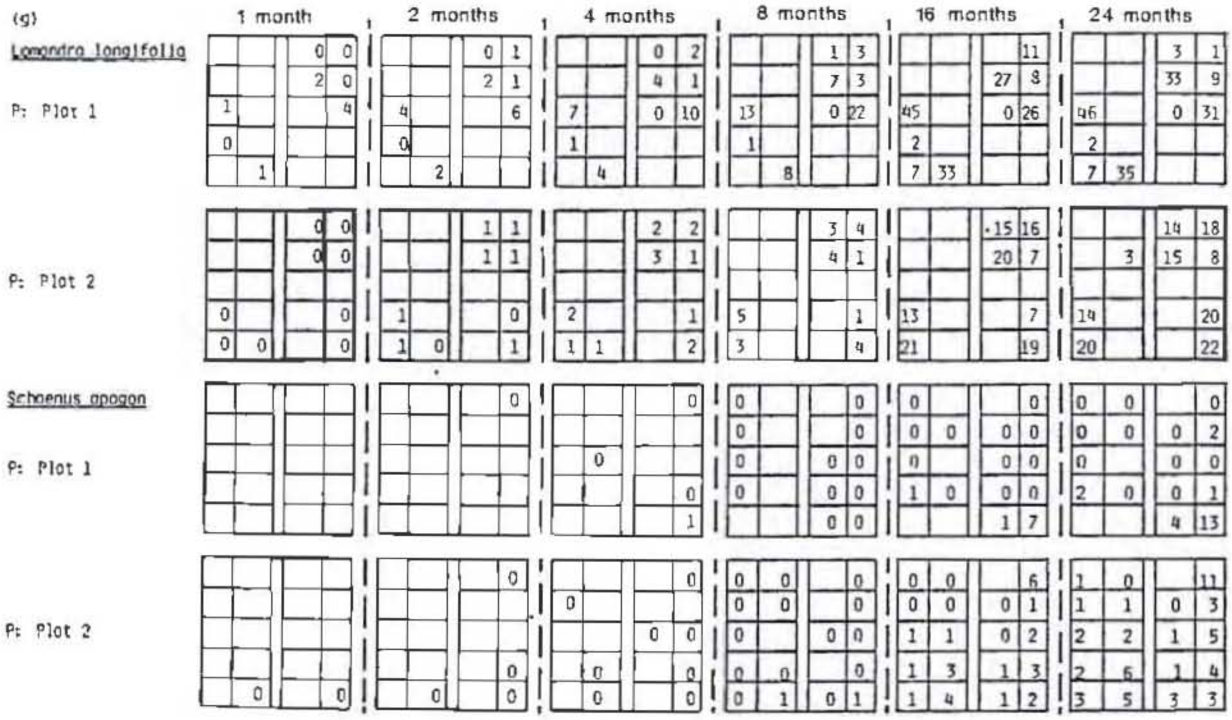

(f)
Eucalyptus obliqua
0: Plot 1
0: Plot 2
Gramineae
0: Plot 1
0: Plot 2
1 month
2 months
4 months
8 months
16 months
24 months

Fig. 16 contd.


(g)
1 month
2 months
4 months
8 months
16 months
24 months
Lomandra longifolia
P: Plot 1
P: Plot 2
Schoenus apogon
P: Plot 1
P: Plot 2

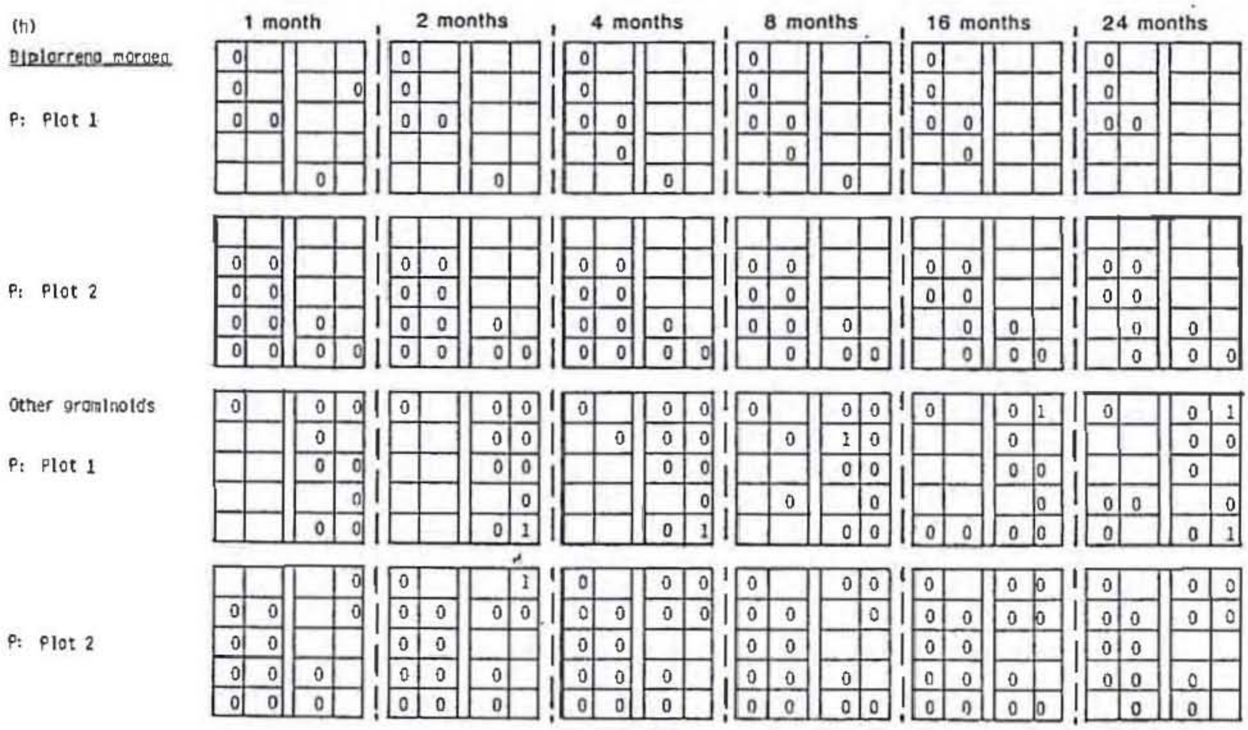
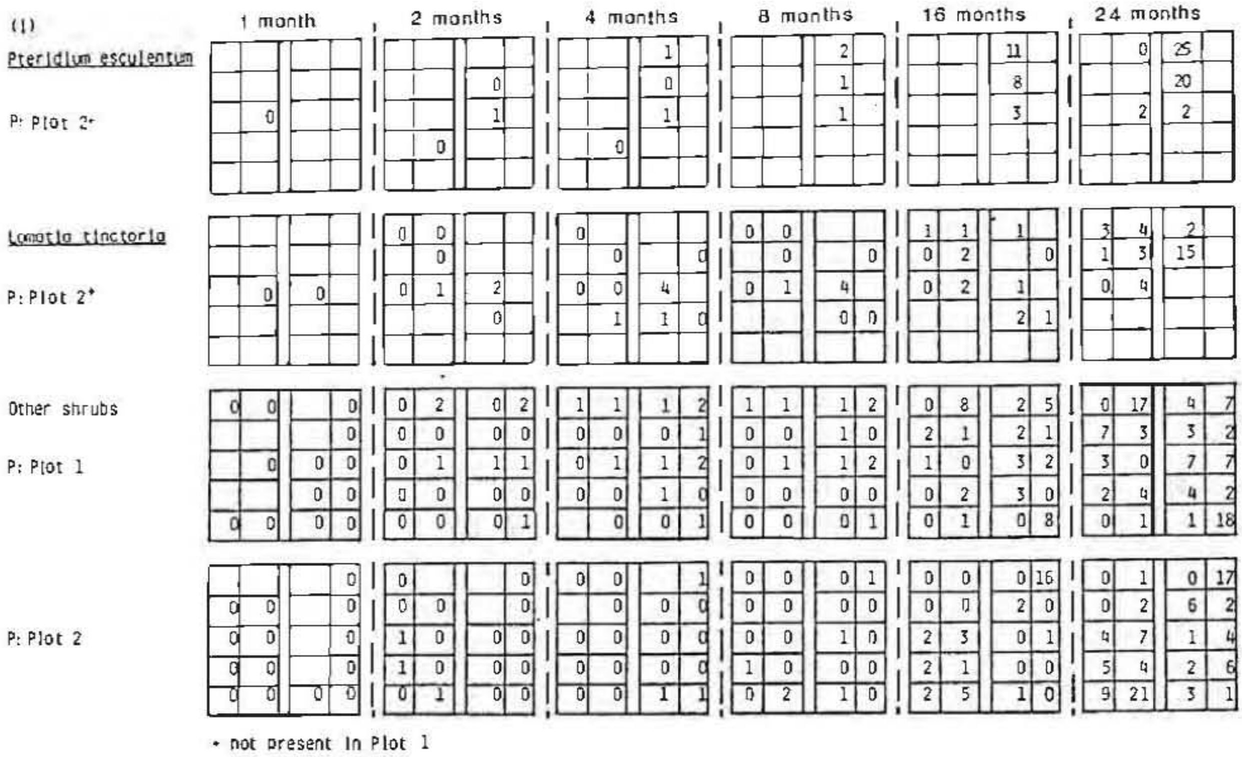

(h)
1 month
2 months
4 months
8 months
16 months
24 months
Diplarrena moraea
P: Plot 1
P: Plot 2
Other graminoids
P: Plot 1
P: Plot 2

Fig. 16 contd.


(i)
Pteridium esculentum
P: Plot 2*
Lomatia tinctoria
P: Plot 2*
Other shrubs
P: Plot 1
P: Plot 2
1 month
2 months
4 months
8 months
16 months
24 months
* not present in Plot 1

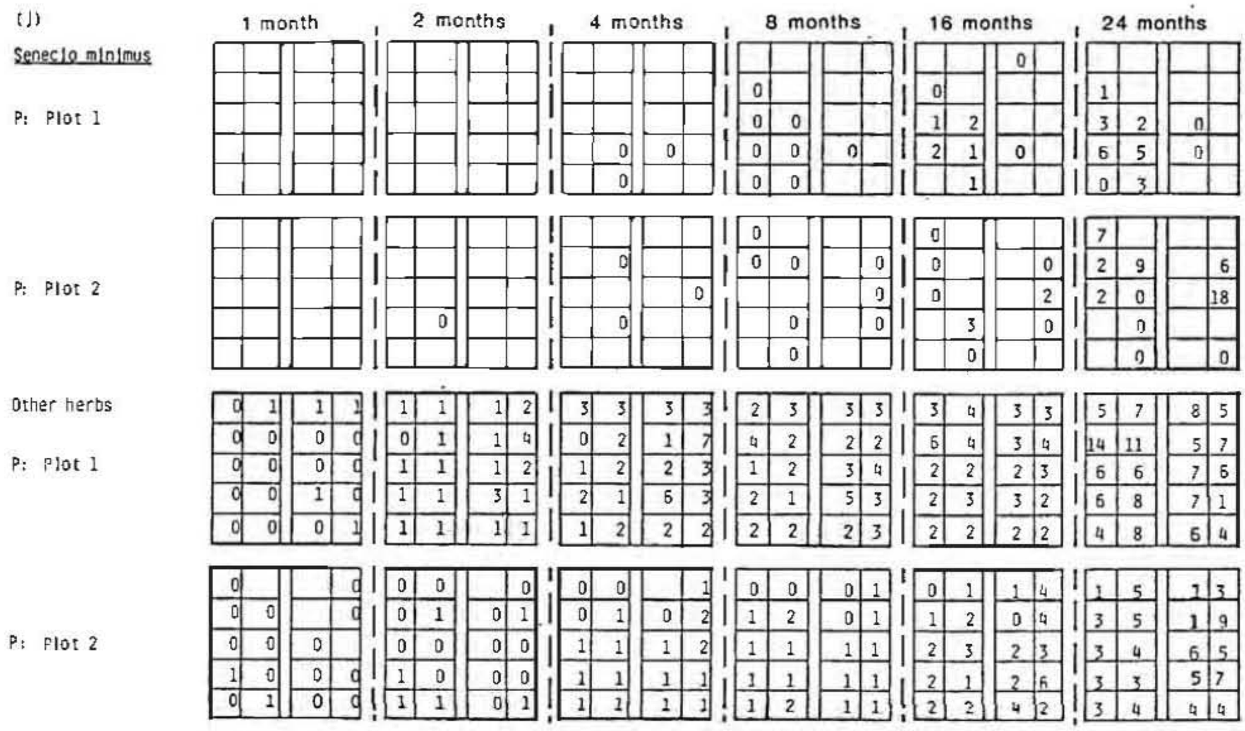
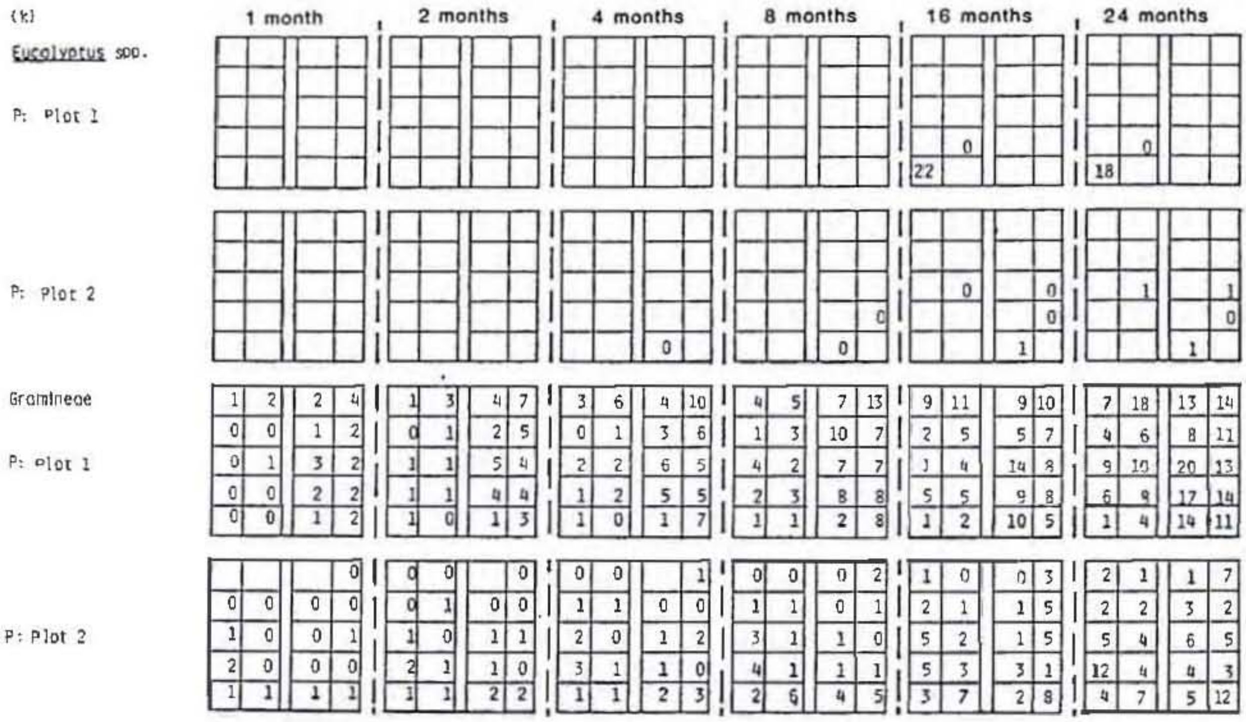

(j)
Senecio minimus
P: Plot 1
P: Plot 2
Other herbs
P: Plot 1
P: Plot 2
1 month
2 months
4 months
8 months
16 months
24 months

Fig. 16 contd.


(k)
1 month
2 months
4 months
8 months
16 months
24 months
Eucalyptus spp.
P: Plot 1
P: Plot 2
Gramineae
P: Plot 1
P: Plot 2

The distribution of Diplarrena moraea and the group `other graminoids' are similar between areas burnt by high and low fire intensity classes. Distribution in the permanent plots of Diplarrena and the latter group of species fluctuates through time, as also observed in type O quadrats.

2.5.2.6 Structural variation

The heights of understorey species and slash present on the permanent plots in each vegetation type, treatment and control in January 1984 are depicted diagramatically in Fig. 17. Treatment UB and the control C, show a greater structural range than does treatment B. The latter treatment lacks the shrubs and trees present in the former cases.

Graminoids are the tallest species in type O, treatment B, with Gahnia grandis showing rapid growth in height to a level greater than that which is present on the control. Senecio minimus and Cirsium vulgare are taller on treatment B than on either treatment UB or the control C, where the two species have either insignificant cover or are absent.

Pteridium esculentum, Lomandra longifolia and Lomatia tinctoria have achieved heights on treatment B similar to those present on treatment UB and the control C. Species within type O had greater heights than the same species in type P under treatment B. Grass inflorescences are taller in type P than in type O on treatments B and UB, and on the control sites (see Chapter 3). The height of slash was greater in type O than in type P.

2.5.2.7 Eucalypt regeneration

Eucalypt density is variable. However, density on treatment B at MM14 is consistently significantly less ($p = 0.02$) than other ages of

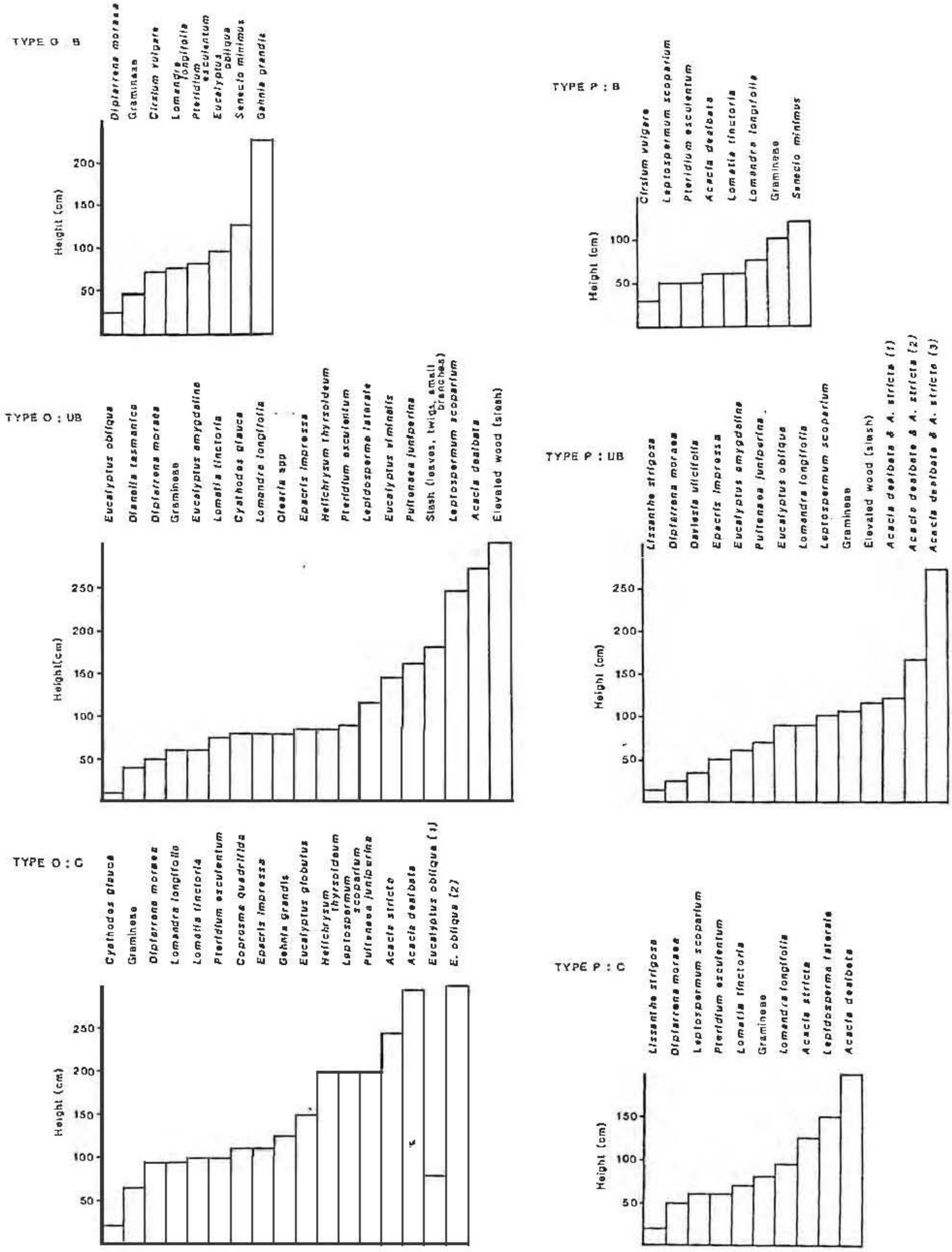


Fig. 17 : The heights (cm) of the understorey species and slash present on the permanent plots in each vegetation type (P and O), treatment (B and UB) and control (C) at MM14. All records were obtained in January 1984. Measurements of Gramineae correspond to heights of inflorescences. (1),(2), or (3) indicate that the species was present in several disjunct height classes.

regeneration in both vegetation types (Table 7A). The advanced growth on treatment UB is significantly less dense than the regrowth at TO2 and at MM20 ($p = 0.02$) except for type P where MM20 regeneration is not statistically different at $p = 0.05$.

Mean basal area is significantly greater on treatment UB than on B in type O at MM14 ($p = 0.02$) but does not differ significantly at $p = 0.05$ from either the 5 or 9 year-old regeneration. The regeneration on treatment UB, type P at MM14 differs significantly only from the 9 year-old regeneration at $p = 0.02$. The regrowth in type P on treatments B and UB, MM14, and at MM20 do not differ significantly from each other at $p = 0.05$.

The mean height of regeneration is similar between the regrowth on treatment UB at MM14 and the 5 year-old regrowth at MM20 in both vegetation types. The 9 year-old regeneration at TO2 is significantly greater ($p = 0.02$) than all other ages of regrowth in type P and type O.

In general, the regeneration in type O is of greater mean height and basal area than the regrowth present in type P associations.

The percentage frequencies of the eucalypt regrowth measured at MM14 according to 5 broad categories of regeneration type are shown in Table 8. Sources of regeneration were not significantly different ($p = 0.05$) between vegetation types P and O on treatment B. However, the nature of regeneration differed significantly ($p = 0.001$) in type P between treatments B and UB, in type O between treatments B and UB, and on treatment UB between type P and type O. Regeneration from seed was more frequent in type O than in type P on treatment UB, with most occurring on mechanically disturbed ground. Regrowth from lignotubers was more evident on treatment B than on treatment UB where advanced regeneration was already established.

The percentage frequencies of seed and lignotuber development were more similar in vegetation type P than in type O for both treatments. Percentage values for seed and lignotuber regeneration were greater on

(A)

Coupe	MM14		MM20	TO 2	MM14		MM20	TO 2
Treatment	Burnt-sown	Unburnt-nat. reg.	Burnt-sown	Burnt-sown	Burnt-sown	Unburnt-nat. reg.	Burnt-sown	Burnt-sown
Age of regeneration	2	2 (Adv.)	5	9	2	2 (Adv.)	5	9
Vegetation type	P	P	P	P	O	O	O	O
Mean density (eucs/100m^2)	3.72	15.04	13.06	31.35	3.21	9.61	35.05	25.31
Mean basal area/individual (cm^2)	2.18	2.53	3.48	5.84	5.58*	4.75	2.42	10.33
Mean height (m)	0.64	0.68	0.86	1.33	0.66	0.98	0.85	1.63

(B)

Coupe	TO 56		TO 30	
Treatment	Burnt-sown	Unburnt-nat. reg.	Burnt-sown	Unburnt-nat. reg.
Age of regeneration	7	7 (Adv.)	8	8 (Adv.)
Vegetation type	D/O	D/O	D/O	D/O
Mean density (eucs/100m^2)	19.74	11.22	5.66	11.11
Mean basal area/individual (cm^2)	4.21	44.66	21.81	31.69
Mean height (m)	1.12	2.62	1.96	3.22

TABLE 7 : Mean figures for eucalypt density /100m^2, basal area (cm^2) and height (m) for the various dry forest coupes. Significance levels of the differences between values in the different ages of regeneration and treatments are denoted by the lines, the end points of which correspond to the particular comparisons under consideration.

▲—▲ sig. at 0.02, △---△ sig. at 0.05 only. * Mean value inflated due to one large result. NS = not significant.

Adv. = Advanced natural regeneration. Nat. reg. = Natural regeneration.

(A) Vegetation types P and O; (B) Vegetation type D/O.

MM14

	VEGETATION TYPE									
	P					O				
	Percentage frequency					Percentage frequency				
	Coppice	Basal resprout	Lignotuber	Seed	Advanced	Coppice	Basal resprout	Lignotuber	Seed	Advanced
Treatment B	2	7	37	42	12	-	6	31	57	6
Treatment UB	1	4	27	26	42	2	7	8	40	43

TABLE 8 : Percentage frequency of the eucalypts measured at MM14, January 1984, in each of 5 broad categories of regeneration.

treatment B than on treatment UB for both vegetation types. Developed advanced regeneration was the most frequent form of regrowth on treatment UB in type P and type O. Lignotuber resprouts were more common in type P than in type O under treatment UB.

Significance relationships for the regeneration present on the high altitude coupes in type D/O are presented in Table 7B. The density of eucalypts is greatest ($p = 0.02$) on the burnt treatment with 7 year-old regeneration (T056). The other values of density do not differ significantly from each other at $p = 0.05$.

Mean basal area is similar between the two unburnt treatments but both differ significantly at $p = 0.02$ from regeneration on the burnt sites.

The 7 year-old burnt treatment has a high density of eucalypt regeneration but low mean basal area whereas the converse is true for the other three regrowth categories.

The mean height of the eucalypt regeneration is greatest ($p = 0.02$) on the unburnt 8 year-old sites compared with the other regeneration sampled in type D/O. The unburnt 7 year-old regeneration differs significantly ($p = 0.02$) in height from the equivalent burnt treatment but shows no significant difference at $p = 0.05$ from the 8 year-old burnt treatment.

The absolute frequencies (see section 2.3.6) of the particular eucalypt species present on each coupe that was sampled are shown in Table 9. Species composition differed from site to site, and between treatments. The composition of eucalypt species on treatment B differed ($p = 0.001$) from the expected composition resulting from the artificially sown seed mix alone (i.e. 75% E. obliqua, 15% E. amygdalina, 10% E. globulus) in both vegetation types P and O. The occurrence of eucalypt species other than those present in the sown seed mix was substantial in both types P and O, the absolute frequency being greater in the former. The absolute frequency of E. obliqua was significantly less ($p = 0.001$) in type P than in type O,

(A)

Coupe	MM14				MM20		TO 2		MM14				MM20		TO 2	
Treatment	Burnt-sown		Unburnt-natural		Burnt-sown		Burnt-sown		Burnt-sown		Unburnt-natural		Burnt-sown		Burnt-sown	
Vegetation type	P		P		P		P		O		O		O		O	
	Absolute frequency of eucalypt species															
	Sp.	%	Sp.	%	Sp.	%	Sp.	%	Sp.	%	Sp.	%	Sp.	%	Sp.	%
	E.pu	60	E.am	81	E.pu	88	E.pu	88	E.ob	96	E.ob	84	E.ob	100	E.ob	96
	E.ob	56	E.vim	58	E.ob	64	E.ob	60	E.glob	22	E.am	28	E.vim	24	E.pu	60
	E.vim	48	E.pu	50	E.vim	20	E.del	28	E.cord	11	E.vim	28	E.pu	16	E.vim	24
	E.am	44	E.ob	27	E.glob	16	E.glob	12	E.vim	7	E.glob	20	E.glob	8	E.glob	16
	E.cord	20	E.glob	4	E.cord	8	E.vim	4	E.pu	4	E.pu	16	E.brook	4	E.del	4
	E.rub	8			E.ten	4										

(B)

TO 56				TO 30			
Burnt-sown		Unburnt-natural		Burnt-sown		Unburnt-natural	
D/O		D/O		D/O		D/O	
Absolute frequency of euc. species							
Sp.	%	Sp.	%	Sp.	%	Sp.	%
E.del	68	E.del	100	E.ob	72	E.del	76
E.ob	44	E.vim	20	E.del	68	E.vim	44
E.vim	20	E.ob	8	E.vim	28	E.pu	20
E.pu	16	E.pu	4	E.brook	20	E.ob	16
E.dal	16	E.dal	4	E.pu	12		
				E.glob	4		

TABLE 9: Absolute frequency of eucalypt species in variously aged dry forest regeneration, with and without slash-burning, using the point-centred quarter method.(Mueller-Dombois & Ellenberg,1974).(A) P= E.pulchella dominated vegetation type;
O= E.obliqua dominated;
(B) D/O= E.delegatensis/E.obliqua dominated.

E.pu - E.pulchella; E.ob - E.obliqua; E.vim - E.viminalis; E.am - E.amygdalina; E.cord - E.cordata; E.rub - E.rubida; E.glob - E.globulus; E.ten - E.tenuiramis; E.del - E.delegatensis; E.brook - E.brookerana; E.dal - E.dalrympleana.

while the reverse was true for E. pulchella. E. amygdalina was not recorded in type O. E. cordata and E. rubida records on treatment B reflect a local restricted population regenerating from lignotubers or from basal resprouts.

The significant difference between the observed and expected species composition was not surprising given the relative importance of on-site regeneration sources other than seed in both types P and O on treatment B (Table 8). Thus, the species composition of the regeneration from seed alone was tested for significant difference (chi-squared: $p = 0.05$) from the species composition to be expected from the sown seed mix. It was found that the type P seed regeneration did not differ significantly ($p = 0.05$) in species composition from the seed mix but that type O seed regeneration did differ significantly at $p = 0.001$. In the case of the latter all seed regeneration recorded was of E. obliqua.

E. delegatensis is dominant in the advanced regeneration present on T056 and T030. However, the unburnt sections were left initially because of the good advanced regeneration of this high quality timber species.

2.6 DISCUSSION

2.6.1 Environmental control of floristic variation

The effects of variation in moisture availability and drainage on the distribution of dry forest eucalypt species in Tasmania have been noted elsewhere (e.g. Hogg and Kirkpatrick, 1974; Duncan, 1981b). In the study area at Mt. Morrison, communities dominated by Eucalyptus obliqua occupy sites of relatively high moisture availability whereas communities dominated by E. pulchella are restricted to relatively dry localities.

E. obliqua is widely distributed in wet gullies and on south-facing slopes within the dry forests of southeastern Tasmania (Duncan, 1981b). At MM14, type O communities are not confined to the aforementioned habitats but intergrade with type P associations in localised depressions. These concavities have greater available moisture than the dry, often rocky, ridges and well insolated northerly aspects where type P communities occur.

2.6.2 The impact of slash-burning - treatment B

Species able to resprout vegetatively recovered the most rapidly after burning. On moist sites in particular, that is in type O communities, regrowth of species with fire-protected rootstocks was rapid. Rhizomatous species such as Lomandra longifolia, Pteridium esculentum and Lomatia tinctoria also resprouted rapidly following the slash-burn. The best example of vegetative recovery was given by Gahnia grandis which was very successful especially in the areas of high intensity burn, except for the portions which had severely fire-baked soil. G. grandis possesses closely compacted basal shoots which restrict fire incursion to the reproductive core of the plant by the exclusion of oxygen, despite a highly flammable aerial growth morphology (see Chapter 5).

In contrast, species with shallow root systems or rootstocks, for example the herbs and grasses, are more susceptible to fire damage.

The post-fire success of species with vegetative recovery mechanisms has been widely reported elsewhere. Post-fire jarrah forest, and heathland vegetation are almost immediately populated by rootstock regeneration, with 69% of species being capable of vegetative recovery in the former community (Bell and Koch, 1980) and 73% in the latter (Russell and Parsons, 1978). Figures for Californian chaparral are lower with 44% of species having rootstock regeneration (Hanes, 1971).

In lightly burnt areas at MM14, shallow rooted species, particularly the grasses and herbs, recovered rapidly. For example, Haloragis tetragyna increased in population size on treatment B, as well as on treatment UB. H. tetragyna can sucker from exposed or partly damaged roots (Purdie and Slatyer, 1976). Similar population increases in H. tetragyna were observed by Loyn et al. (1983). At MM14, grasses and herbs had a marked increase in cover 16-24 months post-fire in areas burnt by the range of fire intensities. This phenomenon is consistent with the general observation that many species of grasses and herbs flower in great profusion in the first or second season post-fire (Daubenmire, 1968). Heavy seed set of certain species was apparent at MM14 after 12 months, as has also been reported by Purdie and Slatyer (1976) for the grasses Poa spp. and Dichelachne sciurea. Regeneration behaviour following fire is closely linked with season, and response to water availability (Naveh, 1975). In addition, the time of burning is important because if the perennating buds are at or near the surface then the susceptibility to damage is high (Daubenmire, 1968).

Species of Orchidaceae may have their perennating bulbs destroyed by heat stress during fire (Purdie and Slatyer, 1976). However, only Caladenia catenata was recorded before the slash-burn but not after (type P: Appendix 2). The reverse was true for Eriochilus cucullatus (type O), which may have been seasonally absent during the pre-burn floristic survey.

Shrub and tree species at MM14 recovered vegetatively from lignotubers, for example Leptospermum scoparium, and from subterranean buds present on roots, for example Acacia dealbata (as noted by Gill, 1975). The rapidity of growth was greatly affected by the intensity of the burn, moisture availability, and selective grazing and browsing (see Chapter 3).

Regrowth from seed following the slash-burn was delayed (group 4: section 2.5.2.2) when compared to vegetative reproduction. Regeneration may occur from residual soil-stored seed banks or from wind or animal dispersed propagules. The high percentage of bare ground following the fire (Fig 13a) in both vegetation types enabled successful establishment of such opportunistic species as Senecio minimus (also noted by Loyn et al., 1983). This short-lived perennial, absent before the slash-burn on treatment B, grew rapidly after the fire, particularly on the type 0 plots. West and Chilcote (1968) in studies of slash-burnt sites in Oregon, found that Senecio sylvaticus rapidly invaded following the fire, peaking in dominance after 2 years. In this case, the success of S. sylvaticus was attributed to an abundance of small, aerially disseminated seed plus the low competitive ability and high nutrient requirement of the species, which were both satisfied in the immediate post-burn environment.

Other species which were successful post-burn colonisers at MM14 were the exotics Cirsium vulgare, Sonchus asper and Hypochaeris radicata. All are known to have wind dispersed seed and H. radicata may also resprout from roots (Purdie and Slatyer, 1976). Cirsium vulgare is a cosmopolitan invader of disturbed areas, for instance Dyrness (1973) found that the species was common on sites following logging and burning in Oregon. With the exception of Astroloma humifusum and Pratia pedunculata (group 4(vi): section 2.5.2.2), all species with delayed post-fire establishment were not recorded prior to the slash-burn (see Appendix 2).

Heat from fire may act as a stimulant to germination of viable seed by softening or cracking hitherto impermeable testa (Beadle, 1940; Christensen and Kimber, 1975). Nevertheless, the effects depend on the temperature, and duration of thermal energy (Floyd, 1966). Fire may also remove inhibitors of seed germination present in the unburnt vegetation (Purdie, 1977b). However, longevity and loss of seed viability will affect the size of the germinable seed bank (Purdie, 1976). Grime (1979) observed that in areas of frequent and extensive disturbance, for instance following fire or grazing, it is not unusual to find represented in the flora, species in which regeneration involves a persistent seed bank. Some data are available on the effects of heat on soil-stored seed of species encountered in the present study. Warcup (1980) reported increased germination in heat-treated soil compared to untreated, for species of Juncaceae and Cyperaceae, _Opercularia varia_, _Deyeuxia quadriseta_, _Acacia_ spp., _Bossiaea prostrata_, _Pultenaea_ spp., _Epacris impressa_ and _Poranthera microphylla_. Results from the present study concur with these data only if considerations of differing moisture availability, as well as grazing and browsing are taken into account. _Poranthera microphylla_ was not present on the treatment B plots. _Epacris impressa_ did not recover well in either type P or type O and was slow to re-establish (also observed by Duncan, 1981a; Loyn _et al._, 1983).

In areas where burning resulted in pronounced soil baking, little regeneration occurred. When large logs are rotten and have dried out on the ground, ignition may cause higher local soil temperatures than those experienced elsewhere in the general area (Gill, 1981). On dolerite, lingering fire bakes and hardens the soil, decreasing surface permeability and increasing subsequent runoff. High percentage cover of bare ground remained in areas of pronounced soil baking at MM14. Log piles, particularly characteristic of log landing margins and roadsides, experienced prolonged burning and severe baking (see also Tunstall _et al._, 1976). Plant cover on areas of lingering intense fire was restricted, with little or no colonization in the 24 months following the slash-burn. Where plant cover did increase, it was invariably due to the establishment and growth of individuals on the margins where soil baking was less intense. This phenomenon was also reported by Gill (1981). Dyrness (1973) noted that total cover on severely burnt plots constantly lagged behind the cover present on lightly burnt sites or on those areas which were disturbed but remained unburnt.

The literature suggests that baking by fire effectively sterilizes the soil, thereby favouring eucalypt establishment (Duncan, 1981a). At MM14, the regeneration of eucalypts (from all regeneration sources) was not concentrated on sites which had been burnt intensely when compared to the sites of lighter burn (p = 0.05) (section 2.5.2.5). Neither did the eucalypts establish on severely baked soils.

2.6.3 The impact of logging - treatment UB

Some interspecific variation was observed in response to the removal of the eucalypt overstorey and the concurrent mechanical disturbance.

A number of species showed an increase in growth 4-12 months after the time of the slash-burn, for example *Lomatia tinctoria*, *Viola hederacea*, *Danthonia* spp., *Pentapogon*/*Dichelachne*, *Poa* spp., *Hydrocotyle javanica* and *Festuca asperula*. *Haloragis tetragyna*, *Plantago varia*, *Eucalyptus amygdalina* and *E. viminalis* increased rapidly in cover from 17-24 months post-fire, which spanned the spring of 1983. A degree of intraspecific variation was also observed. Individual plants which escaped destruction, damage or total suffocation from slash, responded to increased insolation and greater available moisture. Overall, marked growth increases of particular species were generally not sustained consistently throughout the study period.

Acacia stricta suffered considerable dieback particularly 16-24 months after the time of the slash-burn. Fungal baiting of soil samples collected from the base of the diseased plants, failed to identify the fungal pathogen responsible beyond the exclusion of *Phytophthora cinnamomi* (C. Palzer, personal communication), which has spread into many Tasmanian native plant communities (Brown and Podger, 1982). Dieback of *A. stricta* was also observed within non-clearfelled forest elsewhere in the region of MM14. Thus, it cannot be firmly concluded that *A. stricta* was suffering from disease contracted as a result of the clearfelling operation. The dieback may have been caused by a widespread fungal pathogen affecting the species, or by natural senescence.

Some invasion of exotic species was recorded on treatment UB, for example Cirsium vulgare, Hypochaeris radicata and Leontodon leysseri. However, the cover and incidence of these species was less than that observed on treatment B. Therefore, it could be concluded that disturbance from clearfelling and slash-burning favoured the establishment and persistence of exotic species to a greater degree than clearfelling alone. Exotic species were infrequent on the control sites.

Regrowth was slight on log landings, where soil disturbance and compaction was common. Poor revegetation in these areas has also been documented by Loyn et al. (1983). In addition, snig tracks (tracks left as a result of log haulage) showed little regeneration of vegetation on treatments B and UB, 24 months after logging. Ruts were exposed to bedrock on certain parts of the tracks, whilst on other parts, erosion and deposition was a continuing process.

2.6.4 The control areas

Little change occurred in cover of understorey species in the control areas. Pteridium esculentum fluctuated in cover due to rapid changes in the proportions of live to dead, and cured, material (see group 1(ii): section 2.5.2.2).

Certain graminoids and herbs maintained growth increases, for example Gahnia grandis and Plantago varia. However, some shrub species senesced, particularly Acacia stricta, Helichrysum thyrsoideum and Pultenaea juniperina. Leptospermum scoparium decreased in cover 8-24 months after the time of the slash-burn. The herb, Haloragis teucrioides also showed some degree of senescence. The leguminous species, Acacia stricta was affected by insect galls on individuals in the type O community. Legumes are short-lived species which die out after approximately 15 years in dry sclerophyll forests (Shea et al., 1979). Senescence of shrub species has been noted in dry sclerophyll vegetation with a 32 year fire-free period (Purdie, 1977a), and in Western Australian forest communities with a 25-30 year fire-free period (Bridgewater and Backshall, 1981).

2.6.5 Species diversity and species richness

Studies using the index of diversity H', report similar trends to those found in the present study. Duncan (1981a) found that dry forest understorey species had successfully colonised 17 months after the slash-burn, with values of H' exceeding pre-burn values on all sites, and in all cases of fire intensity. Loyn et al. (1983) showed that H' reached a maximum 4-10 years after disturbance in Victorian clearfelled forests. Similarly Shafi and Yarranton (1973) in studies of boreal forest communities, reported that values for H' were high 4-11 years after burning, and attributed recorded fluctuations to variations in species richness. At MM14, there was no evidence to indicate that H' diversity was stabilising 24 months after the slash-burn.

In a study of a dry sclerophyll to wet sclerophyll forest transition elsewhere in southeastern Tasmania, values of the diversity index N_2, were found to be 4.8 and 5.8 respectively (Raine, 1984). These are comparable with N_2 values at MM14 on treatment UB and the control C, particularly in the type P plots.

Results from both diversity measures indicate that disturbance from clearfelling and slash-burning caused marked fluctuation in species presence-absence, relative interspecific cover and dominance. The community is in a state of flux for at least 24 months following burning.

Increased species richness following fire has also been observed by other workers (e.g. Dyrness, 1973; Bell and Koch, 1980; Posamentier et al., 1981; Loyn et al., 1983). Russell and Parsons (1978) found no obvious decline in species richness for at least 10 years after fire in heathland communities whilst Shafi and Yarranton (1973) documented an increase 4-11 years after burning in boreal forest. However, Purdie and Slatyer (1976) and Purdie (1977a, 1977b) recorded few additional species following burning in a low intensity fire regime in dry sclerophyll vegetation. Posamentier et al. (1981) attribute the absence of change in species richness in the latter studies compared with the former, to differences in fire intensity and frequency of burning. It must be noted however, that variables extraneous to particular fire intensities and frequencies, such as between-site environmental variation and climatic differences, will also confound comparison of results obtained in different studies.

Of the additional species recorded at MM14 on treatment B, during the 24 months following the slash-burn, 73% (type P) and 74% (type O) were herbs, graminoids and grasses. Only 12% (type P) and 18% (type O) were shrub and tree species. By way of comparison, Dyrness (1973) described considerable invasion of species in the herbaceous layer following logging and burning in Oregon. Similarly, Steen (1966) found that after the first 5-7 years following slash-burning shrub cover was less on burned areas than on adjacent unburned sites.

The proportions of species present pre-burn to those present post-burn under treatment B at MM14 are similar to those documented in other studies. For example, Purdie (1977a) found that 50-75% of pre-burn plants were present within 2 months of burning, and Posamentier et al. (1981) recorded that 75-80% of pre-burn species were present 3 to 4 years post-burn.

For the purposes of the present study the measure of species richness was far more informative than the species diversity measures, H' and N_2. The pulses in growth of certain species was obvious and little interpretation of the causes of diversity fluctuation could be made beyond this level. Comparison with other results contained in the literature are confounded considerably by variations in data collection, quadrat size, species amalgamations, environmental variation existing at the particular sites, and the form of the data used to calculate the diversity measures. It is a conclusion of the present study that species richness is a more ecologically informative measure than either of the diversity indices H' or N_2.

2.6.6 Species density

Interspecific and intraspecific competition, and the effect on establishment, growth and mortality of plant species and individuals has been discussed at length by Harper (1977). The growth rate of a young plant is perceived as likely to be greatest if it; (a) establishes before its neighbours, (b) is well separated from its neighbours, and (c) has weak neighbours. In the present context therefore, species having rapid vegetative propagation are distinctly advantaged. For example, Pteridium esculentum grows rapidly, has the capacity for lateral spread above and below ground, and produces copious quantities of litter. As such, following disturbance species of the genus Pteridium may outcompete other species which establish less rapidly (Grime, 1979).

Harper et al. (1961) described self-thinning patterns of mortality in plant populations where increasing density was associated with higher risk of death. In the present study, as individuals and number of species became more numerous increasing mortality of certain species was observed. Mortality appeared greatest in areas with predominantly grass and herb regrowth, particularly in type P plots, where low intensity burning was common. Patterns of establishment and mortality were influenced greatly by selective predation of certain plant parts and particular plant species. Grazing and browsing had dramatic effects on the success and relative abundance of certain species (see Chapter 3).

Increasing effects of dominance by woody plants during the course of succession can cause progressive reduction in the density of species in the herb layer (Margalef, 1963; Specht, 1969a; Odum, 1971). Reduction in cover of herb species was particularly evident in type O plots on treatment UB and the control C at MM14, where shrub and tree species were dominant.

2.6.7 Eucalypt regeneration

Fifty-eight percent of the eucalypt regrowth in type P, and 43% in type O, on treatment B, was from regeneration other than seed. In general, fire intensities were insufficient to destroy eucalypt lignotubers, especially in the type P associations. Jacobs (1955) pointed out the dependence of dry eucalypt forest regeneration on lignotuberous seedlings while more recently Abbott and Loneragan (1984) have demonstrated the importance of the lignotuber in post-fire regeneration in the jarrah forest of Western Australia. The lignotuber functions as a source of buds (Carrodus and Blake, 1970) and food reserves (Jacobs, 1955). Development from lignotubers or other on-site regrowth (coppice, basal resprouts, established advanced regeneration) has the advantage of maintaining environmentally specific genotypes and phenotypes in the eucalypt population (Duncan, 1981a).

Density of eucalypts established on treatment B after 24 months was less than that present on the other comparable sites surveyed. Rainfall in southeastern Tasmania was well below average in 1982 (section 2.2.4). Lack of sufficient moisture may have impeded successful seed establishment especially in the drier type P areas, where lignotuberous regrowth was significant.

With regard to eucalypt seed only, general observations at MM14 indicated that where establishment occurred and cotyledons persisted, local site characteristics were important. Favoured areas tended to be type O sites which experienced high intensity burn without severe soil baking, but where plants of rapid vegetative propagation did not establish in the first few months after the burn. Other favoured sites were those where mineral soil was exposed but not excessively compacted. However, the majority of the ground disturbed during logging was too compact for plants to gain root. Where establishment did occur, success of species was enhanced if some protection from grazing was afforded by logs or rocks, without inhibiting insolation at the cotyledonary stage.

Eucalypts were more productive in type O than in type P, reflecting the greater moisture availability on the former. Eucalyptus obliqua germinated on Plot 2, type P, however it is possible that lack of moisture, or competition from species adapted to dry sites may impede subsequent growth of this eucalypt, which is characteristic of moist situations.

Lockett and Candy (1984) looked at the early height growth of mixed eucalypt species regeneration, with and without slash-burn management, at four locations in eastern Tasmania. Their data collection involved measurement of the tallest stems in 25 sub-divisions of a stratified one hectare block, these figures being amalgamated to obtain mean dominant height per hectare. Dry unburnt sites had taller eucalypts, inclusive or exclusive of coppice regeneration, than did burnt sites for at least 10 years following the time of the slash-burn. At MM14, established advanced regeneration on treatment UB, 24 months after the time of the slash-burn was similar in height to 5 year-old regrowth at MM20. At the high altitude coupes in type D/O (TO30 and TO56) the mean height advantage was retained by the unburnt treatment over the burnt treatment for at least 8 years after burning. Lockett and Candy (1984) found that eucalypt regeneration on high altitude sites achieved equable heights on burnt and unburnt treatments 7 years after slash-burning. Differences in sampling methodology and site characteristics may account for the differences between the results of the present study and those of the aforementioned authors.

Lockett and Candy (1984) did not consider density, basal area or species composition of eucalypts on their sites. The present study indicates that high density eucalypt establishment can be concurrent with low mean basal area values as evident at MM20 (type O) and TO30 (burnt). With regard to eucalypt composition the proportions of particular species varied from site to site. The species composition of the artificially sown seed mix was most similar to the species present as seed regeneration in type P, but only E. obliqua established successfully on the type O sites. It would appear therefore that the species composition of sown seed is reflected on type P sites, even though these areas tended to be burnt less intensely than type 0 sites where E. obliqua established. The importance of seed provenance in choice of artificially sown seed has been stressed by Duncan (1981a). Little is known of the relative success of seed from alien provenance sources compared with indigenous material. Similarly, the practice of sowing seed from the air with little allowance for local topographic or environmental variation, with respect to establishment and persistence of different species, has received scant attention.

2.6.8 Secondary succession

The disturbance of clearfelling alone induces a markedly different floristic response than the combined disturbance of clearfelling and slash-burning.

The removal of the eucalypt overstorey in the logging operation precipitates intraspecific and interspecific variation in the growth response of understorey species. Local conditions, such as slash cover and the degree of site disturbance, are important in controlling the cover and abundance of species. The eucalypt species are present in the understorey as advanced regeneration, and may also grow as coppice from cut stumps or from lignotubers. In addition, seed from lopped eucalypt heads may germinate, particularly on disturbed sites such as the edges of logging tracks. In the short-term, at least, the disturbance of clearfelling allows the invasion of some alien species. However, after clearfelling without burning there is no marked shift in species composition or relative abundance in the understorey. Clearfelling removes the tallest stratum thereby increasing moisture availability and insolation at ground level. The disturbance, combined with increases in moisture and insolation, allows a flush in growth of certain tree and shrub species, together with some minor increases in herb and grass cover. The latter lifeforms appear to be suppressed in mature forest dominated by E. obliqua.

The results of the present study of clearfelling followed by slash-burning bear greatest similarity to the findings of Posamentier et al. (1981), in that the plant communities are highly resilient (Grime, 1979), with the pre-disturbance dominants surviving, and that there is an increase in quadrat species richness which continues for at least 2 years after the disturbance. However, floristics and relative abundances vary greatly with environmental situation, fire intensity and the regenerative properties of the pre-disturbance species (cf. Noble and Slatyer, 1981).

The dry eucalypt forests on dolerite in southeastern Tasmania do not conform to the relay floristic model of secondary succession, in contrast to such cases as tropical forest (Uhl et al., 1981). Very few species are short-lived post-burn colonisers (e.g. Senecio minimus). The pre-disturbance species are essentially present on the site within 2 years of burning. However, the initial floristic composition model is an inadequate descriptor as quadrat species richness increases following slash-burning.

The succession of species after clearfelling and slash-burning appears idiosyncratic. Local environments, fire intensity, seed availability and the capacity for vegetative propagation all influence species compositions at particular sites (cf. Noble and Slatyer, 1981).

CHAPTER 3

VEGETATION DYNAMICS FOLLOWING CLEARFELLING

II. THE EFFECTS OF GRAZING AND BROWSING

3.1 INTRODUCTION

The effects on plant communities of grazing and browsing have been discussed extensively in the literature. The role of vertebrates as powerful selective agents has been documented within a range of vegetation types (e.g. Drew, 1947; Ellison, 1960; Naveh, 1975; Hobbs and Gimingham, 1980; Selkirk et al., 1983), while the extent and consequences of defoliation by invertebrates has received increasing attention in recent years (e.g. Haukioja, 1980; Fox and Morrow, 1983; McBrien et al., 1983).

Grazing generally reduces the cover of palatable plant species, leading in some instances to accelerated erosion (Bryant, 1971, 1973; Jackson, 1973), whilst unpalatable species achieve dominance. Damage done to a plant growing in isolation may severely impair its growth, affecting both seed set and population expansion. In crowded populations, the effects may be even more severe, particularly if the damage done to individual plants is non-uniform (Harper, 1977).

In Australia, investigations into the grazing of native vegetation by domestic stock have demonstrated a high degree of plant species selectivity. As a result, grazing has a marked influence on community structure and composition (e.g. Carr and Turner, 1959; Bryant, 1971, 1973; Jackson, 1973; Wilson et al., 1975). Studies of predation by native herbivores, vertebrate and invertebrate, in forest communities have concentrated on eucalypt species (e.g. Cremer, 1960; Mollison, 1960; Gilbert, 1961; Greaves, 1966; Cremer, 1969; Carne et al., 1974; Kile, 1974; Springett, 1978; Floyd, 1980; Statham, 1983). There are relatively few data on the influence of grazing and browsing on secondary succession.

The rudimentary understanding of the role of grazing in vegetation succession following fire has been lamented by Leigh and Holgate (1979) and Miles (1981). The former authors cautioned against sweeping statements on the causes of post-fire successional changes in the absence of data on predation.

This chapter tests the hypothesis that clearfelling followed by slash-burning encourages grazing and browsing of dry forest plant species compared to clearfelling alone. Results are reported from investigations into the effects of predation, mainly by vertebrates, on dry forest plant species under the treatments described in the previous chapter.

3.2 METHODS

3.2.1 Fenced exclosures

In November 1982, lm tall fences were erected near to one of the two permanent plots present in each vegetation type, treatment and control, giving a total of 6 exclosures. Fences were located on areas free of slash but closely similar to parts of the nearby permanent plot. The areas fenced were large enough to enclose a lm x lm quadrat without disturbance. Twelve millimetre galvanized birdwire was used to exclude all animals above the size of a rodent (R. Mesibov, personal communication, 1982; Statham, 1983). To prevent animal entry at the base of each fence, a 20cm wire flange, pointing outwards, was created at ground level and weighted down with rocks (Plate 4).

A lm x lm quadrat was demarcated inside the exclosure and all species cover and descriptive features were mapped using the methods described in Chapter 2. Records were made in November 1982, May 1983 and January 1984 (i.e. 10, 16 and 24 months after the slash-burn) on treatment B, and in November 1982, June 1983 and January 1984 on treatment UB and the control C (i.e. 10, 17 and 24 months after the time of the slash-burn). Recording in May/June 1983 and January 1984 was contemporaneous with the main volume of vegetation mapping (Chapter 2).

The maximum heights of shrubs, graminoids and grasses on the fenced plot were noted at each mapping period to enable comparison with heights of the same species on the adjacent permanent quadrat. In addition, oblique photographs were taken of each exclosure at each recording time. The fenced exclosures are shown in Plate 4. Those on treatment B are illustrated for the first and last recording occasions, while the exclosures on treatment UB and the control C are shown for January 1984 only.

The fences were sufficiently robust to exclude the largest native animals. No faecal pellets, or evidence of grazing and browsing, were found inside the 6 exclosures during the course of the study. Some problems were encountered from cattle loose from neighbouring farms, which trampled the wire and broke the corner posts of two fences. However, the damage was quickly repaired and the cattle removed.

3.2.2 Faecal pellet counts

Pellet counts are used as an indication of grazing pressure, in a similar manner to Leigh and Holgate (1979) and Taylor (1980). The technique of counting faecal pellets has also been widely used in wildlife surveys for population and density estimates (e.g. Taylor, 1956; Neff, 1968; Cremer, 1969; Floyd, 1980). In May 1982, all faecal pellets were cleared from each of the permanent plots in type O and type P on treatment B, and also from the plots in type O on treatment UB. Due to the necessary modification of the type P permanent plot system (section 2.3.4), total pellet removal was achieved in September 1982 on treatment UB and the control site.

All faecal pellets were collected from each of the 12 permanent plots concurrent with subsequent mapping (section 2.3.4). Notes were made throughout the permanent plot recording of any evidence of preferential grazing and browsing.

Plate 4 :

(A) The fenced exclosure on treatment B adjacent to Plot 2, type O (see Plate 2) 10 months after the slash-burn (November 1982). Plant cover is generally prostrate. Cover of bare ground and exposed rock is high.

(B) The same fenced exclosure as shown in (A), 24 months after the slash-burn (January 1984). Plant cover inside the exclosure is greater than the nearby unfenced areas. Diplarrena moraea and Helichrysum scorpioides are in flower on the fenced plot but have not flowered on the grazed areas. Gramineae inflorescences are taller and present at a greater density inside the exclosure than on the unfenced areas (see Table 11).

(C) The fenced exclosure on treatment B adjacent to Plot 1, type P (see Plate 2) 10 months after the slash-burn (November 1982). Plant cover is generally prostrate. Cover of bare ground and exposed rock is high.

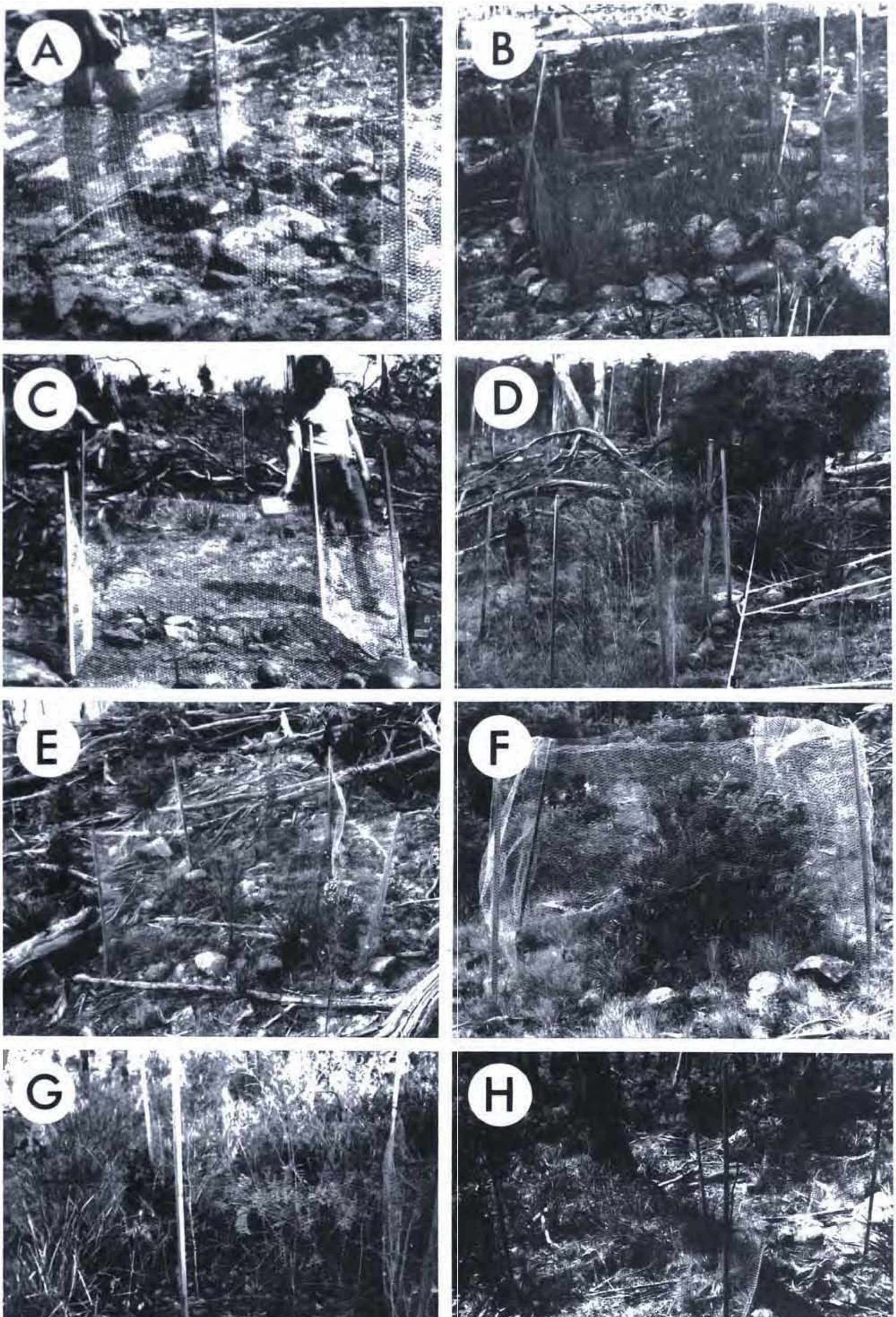
(D) The same fenced exclosure as shown in (C), 24 months after the slash-burn (January 1984). Plant cover is greater on the fenced plot than on the adjacent permanent plot. The density of grass inflorescences is similar on the unfenced and fenced areas, but their height is greater inside the exclosure (Table 11). The tall grass inflorescences pictured are of Stipa pubinodis.

(E) The fenced exclosure in type O on treatment UB, 24 months after the time of the slash-burn (January 1984). Total plant cover on the fenced and unfenced areas remains similar.

(F) The fenced exclosure in type P on treatment UB, 24 months after the time of the slash-burn (January 1984). Total plant cover within the exclosure and on the unfenced areas is similar. The shrub on the fenced plot is Acacia dealbata.

(G) The fenced exclosure in type O in the control C, 24 months after the time of the slash-burn (January 1984). Total plant cover on the fenced plot remains similar to cover on the unfenced areas. Pteridium esculentum (centre right) fluctuated in the proportion of live to dead material during the period of study, but the changes in cover occurred on both the fenced and unfenced areas (section 3.4.1; group 6(iii)).

(H) The fenced exclosure in type P in the control C, 24 months after the slash-burn (January 1984). Overall plant cover remains similar between the exclosed plot and the surrounding unprotected areas.


A
B
C
D
E
F
G
H

type, treatment and control, are categorised into the following 7 groups. Representative examples of each group are illustrated in Fig. 18a. The complete data set is tabulated in Appendix 4.

Lifeform: F = fern; G = grass; Gr = graminoid;
H = herb; O = orchid; S = shrub;
T = tree.
(* = exotic species).

Group 1

This group consists of species which grew rapidly within the fenced area.

(i) Species within this subgroup include those whose increase in cover on the unfenced area was consistently less than on the fenced plot.

Type P		Type O	
B: Schoenus apogon	Gr	B: Diplarrena moraea	Gr
		Goodenia lanata	H
		*Hypochaeris radicata	H
		Poa labillardieri	G
		Pultenaea juniperina	S
		Schoenus apogon	Gr
UB: Oxalis corniculata	H	UB: -	
C: -		C: Microlaena stipoides	G

Group 1 contd.

(ii) Species within this subgroup initially showed similar growth increases on the unfenced area to those shown on the fenced plot until 16/17 months after the time of the slash-burn, but lacked the rapid growth from 16/17-24 months.

Type P			Type O		
B:	Pentapogon/Dichelachne	G	B:	-	
UB:	Bossiaea prostrata	S	UB:	Danthonia spp.	G
C:	-		C:	-	

(iii) These species showed an initial decline in growth, or disappeared on the unfenced area.

B:	-		B:	-	
UB:	-		UB:	-	
C:	Deyeuxia spp.	G	C:	-	
	Stipa pubinodis	G			

Group 1 contd.

(iv) These species did not occur in any of the similar unfenced subplots.

Type P		Type O	
B: Eucalyptus viminalis	T	B: Helichrysum scorpioides	H
UB: -		UB: -	
C: Danthonia spp.	G	C: -	

Group 2

This group consists of species which grew rapidly on both the fenced and unfenced areas.

(i) Species within this subgroup grew at a faster rate on the fenced plot than on the unfenced area until 16/17 months, after which the growth rates were either approximately equal, or greater on the unfenced area than on the fenced plot.

Type P		Type O	
B: Acaena novae-zelandiae	H	B: Viola hederacea	H
Haloragis tetragyna	H		
Poa labillardieri and P. rodwayi	G		
Stipa pubinodis	G		

<u>Group 2(i)</u> contd.

Type P			Type O		
UB:	-		UB:	-	
C:	<u>Bossiaea prostrata</u>	S	C:	-	
	<u>Pimelea humilis</u>	S			
	<u>Lissanthe strigosa</u>	S			

(ii) These species grew at either approximately equal rates or growth was more rapid on the unfenced area than on the fenced plot.

B:	<u>Leptospermum scoparium</u>	S	B:	<u>Microlaena stipoides</u>	G
	<u>Senecio minimus</u>	H			
UB:	-		UB:	-	
C:	-		C:	-	

Group 3

This group includes all species which showed initial growth from 10-16/17 months after the time of the slash-burn on the fenced plot, followed by a decline in cover to 24 months.

(i) On the unfenced area, these species did not show a similar pattern of growth followed by decline that was apparent on the fenced plot.

	Type P ******			Type O ******	
B:	Galium albescens and G. australe	H	B:	Arthropodium milleflorum	Gr
	Lagenophora stipitata	H		Deyeuxia spp.	G
	Opercularia varia	H		Opercularia varia	H
				Pentapogon/Dichelachne	G
UB:	Leptorhyncos squamatus	H	UB:	-	
	Microlaena stipoides	G			
	Wahlenbergia spp.	H			
C:	-		C:	-	

(ii) On the unfenced area, these species grew at a similar rate to that shown on the fenced plot from 10-16/17 months. From 16/17-24 months the growth rate was greater on the unfenced area than on the fenced plot.

B:	Gnaphalium collinum	H	B:	Hydrocotyle javanica	H
UB:	Poa labillardieri and P. rodwayi	G	UB:	-	
C:	-		C:	-	

Group 3 contd.

(iii) This species showed a similar pattern of growth followed by decline on both the fenced and unfenced areas.

	Type P ******			Type O ******	
B:	–		B:	–	
UB:	–		UB:	*Viola hederacea*	H
C:	*Viola hederacea*	H	C:	–	

(iv) These species either did not occur on, or disappeared from the unfenced subplots.

	Type P			Type O	
B:	–		B:	*Goodenia ovata*	S
UB:	–		UB:	*Wahlenbergia* spp.	H
C:	–		C:	–	

Group 4

This group consists of species which showed rapid growth on the unfenced area which was not matched on the fenced plot.

(i) These species showed some fluctuation in growth between the chosen unfenced subplots, but overall the growth rate was greater than that shown on the fenced plot.

	Type P ******			Type O ******	
B:	*Acacia dealbata* *Lomandra longifolia* *Plantago varia*	S Gr H	B:	*Senecio minimus*	H
UB:	–		UB:	*Poa labillardieri*	G
C:	*Themeda australis*	G	C:	–	

Group 4 contd.

(ii) These species disappeared from the fenced plot.

Type P		Type O	
B: *Danthonia* spp.	G	B: -	
Deyeuxia spp.	G		
UB: *Pentapogon*/*Dichelachne*	G	UB: -	
C: -		C: -	

Group 5

This group consists of species which grew rapidly from 10-16/17 months on the fenced plot then remained stable or maintained only slight growth from 16/17-24 months after the time of the slash-burn.

(i) From 10-16/17 months the growth of these species on the fenced plot was greater than or equal to, the growth on the unfenced area. From 16/17-24 months growth on the fenced plot was less than or equal to growth on the unfenced area.

Type P		Type O	
B: *Goodenia lanata*	H	B: -	
Viola hederacea	H		
UB: *Lissanthe strigosa*	S	UB: *Arthropodium milleflorum*	Gr
		Diplarrena moraea	Gr

Group 5(i) contd.

Type P		Type O	
C: Astroloma humifusum	S	C:	-
Festuca asperula	G		
Poa labillardieri and P. rodwayi	G		

(ii) This species had a slower growth rate on the unfenced area compared to the fenced plot from 10-24 months.

Type P		Type O	
B: -		B:	-
UB: -		UB:	-
C: Lepidosperma lineare var. inops	Gr	C:	-

(iii) This species did not occur on the similar unfenced subplots.

Type P		Type O	
B: -		B:	-
UB: Lomandra longifolia	Gr	UB:	-
C: -		C:	-

Group 6

This group includes those species which declined in cover from 10-16/17 months after the time of the slash-burn on the fenced plot and then increased in cover from 16/17-24 months.

(i) On the unfenced area, these species did not have the same pattern of growth and decline that occurred on the fenced plot.

	Type P			Type O	
	******			******	
B:	-		B:	-	
UB:	Plantago varia	H	UB:	-	
	Viola hederacea	H			
C:	Haloragis tetragyna	H	C:	-	
	Hypericum gramineum	H			

(ii) These species appeared after 16/17 months on the unfenced area.

B:	-		B:	-	
UB:	Schoenus apogon	Gr	UB:	Opercularia varia	H
C:	-		C:	-	

<u>Group 6</u> contd.

(iii) On the unfenced area, these species had a similar pattern of growth and decline that occurred on the fenced plot.

Type P ******		Type O ******	
B: *Bossiaea prostrata*	S	B: -	
UB: *Haloragis tetragyna*	H	UB: -	
C: *Plantago varia*	H	C: *Pteridium esculentum*	F

(iv) This species did not occur in the similar unfenced subplots.

B: -		B: -	
UB: -		UB: *Lagenophora stipitata*	H
C: -		C: -	

Group 7

The species within this group had no distinguishable growth difference between the fenced and unfenced areas.

Type P
******

B: *Hypericum gramineum* H

UB: *Acacia stricta* S
Epacris impressa S
Hypericum gramineum H
Leptospermum scoparium S

C: *Acacia dealbata* S
Arthropodium milleflorum Gr
Diplarrena moraea Gr
Lomandra longifolia Gr
Orchidaceae spp. O

Type O
******

B: -

UB: *Lomandra longifolia* Gr
Lomatia tinctoria S

C: *Acacia stricta* S
Coprosma quadrifida S
Danthonia spp. G
Diplarrena moraea Gr
Drosera auriculata H
Epacris impressa S
Festuca asperula G
Haloragis teucrioides H
Helichrysum thyrsoideum S
Hypericum gramineum H
Lagenophora stipitata H
Leptospermum scoparium S
Lomatia tinctoria S
Pultenaea juniperina S
Viola hederacea H

Fig. 18 (a)

GROUP 1 (i)

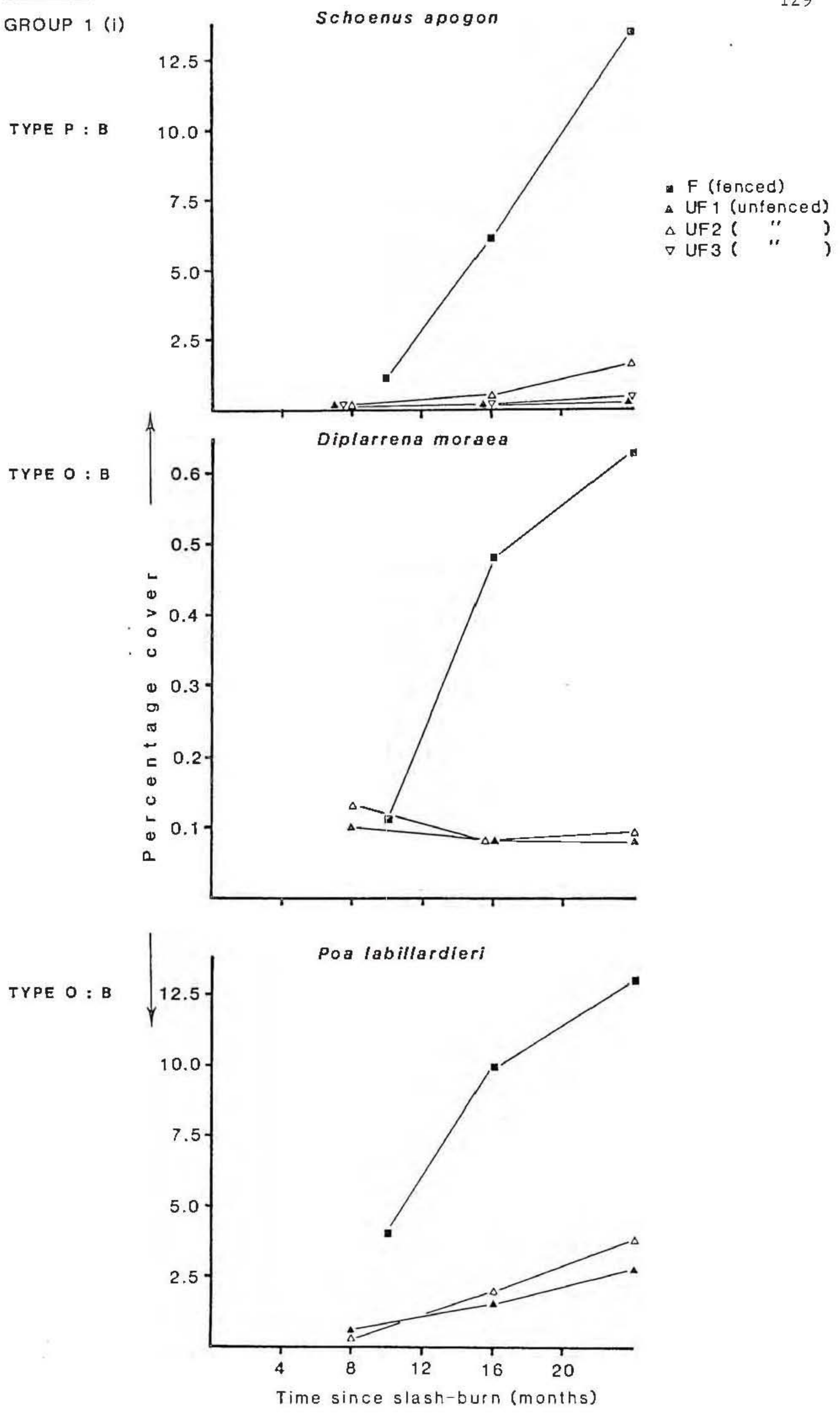


Fig. 18 (a) contd.

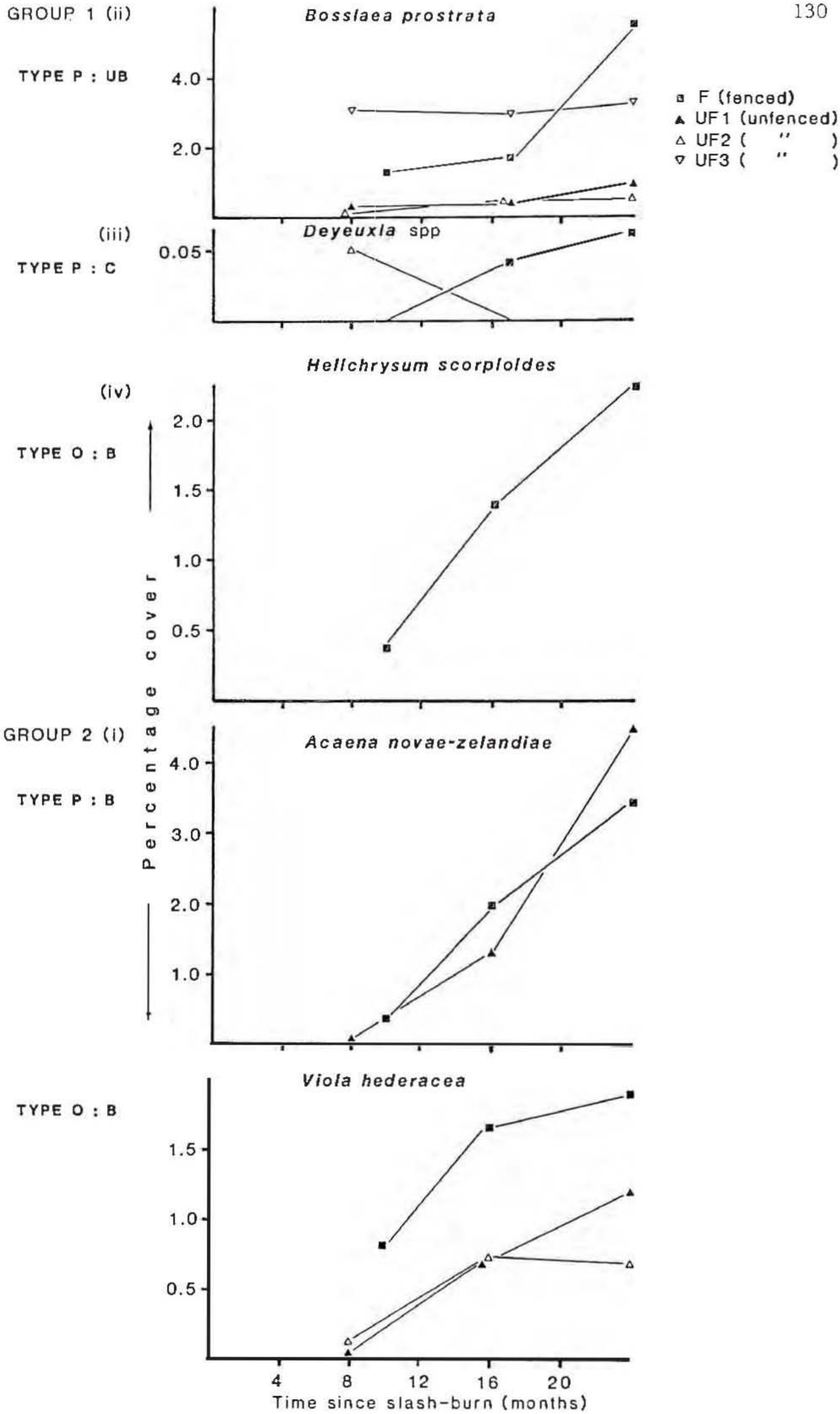


Fig. 18 (a) contd.

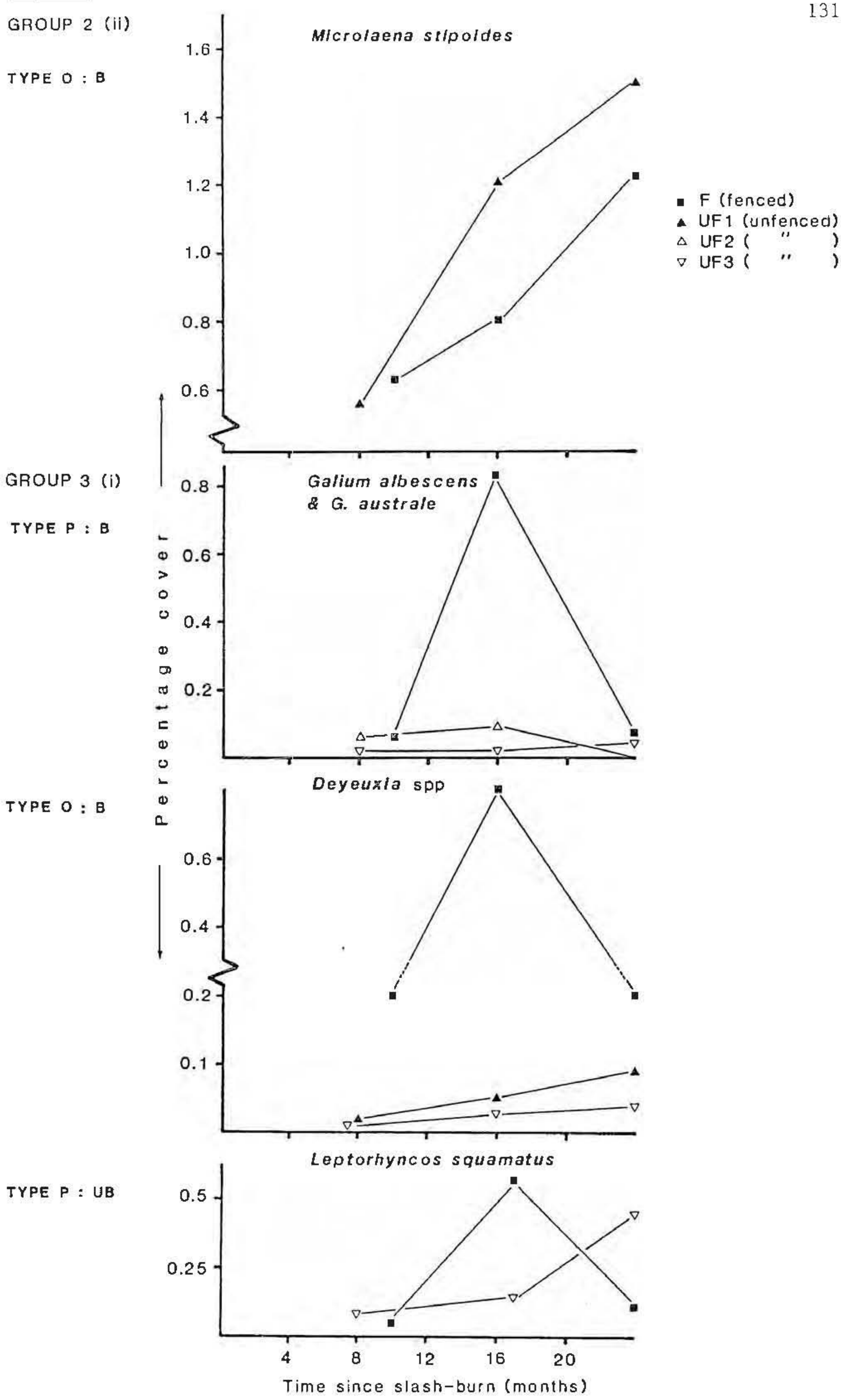
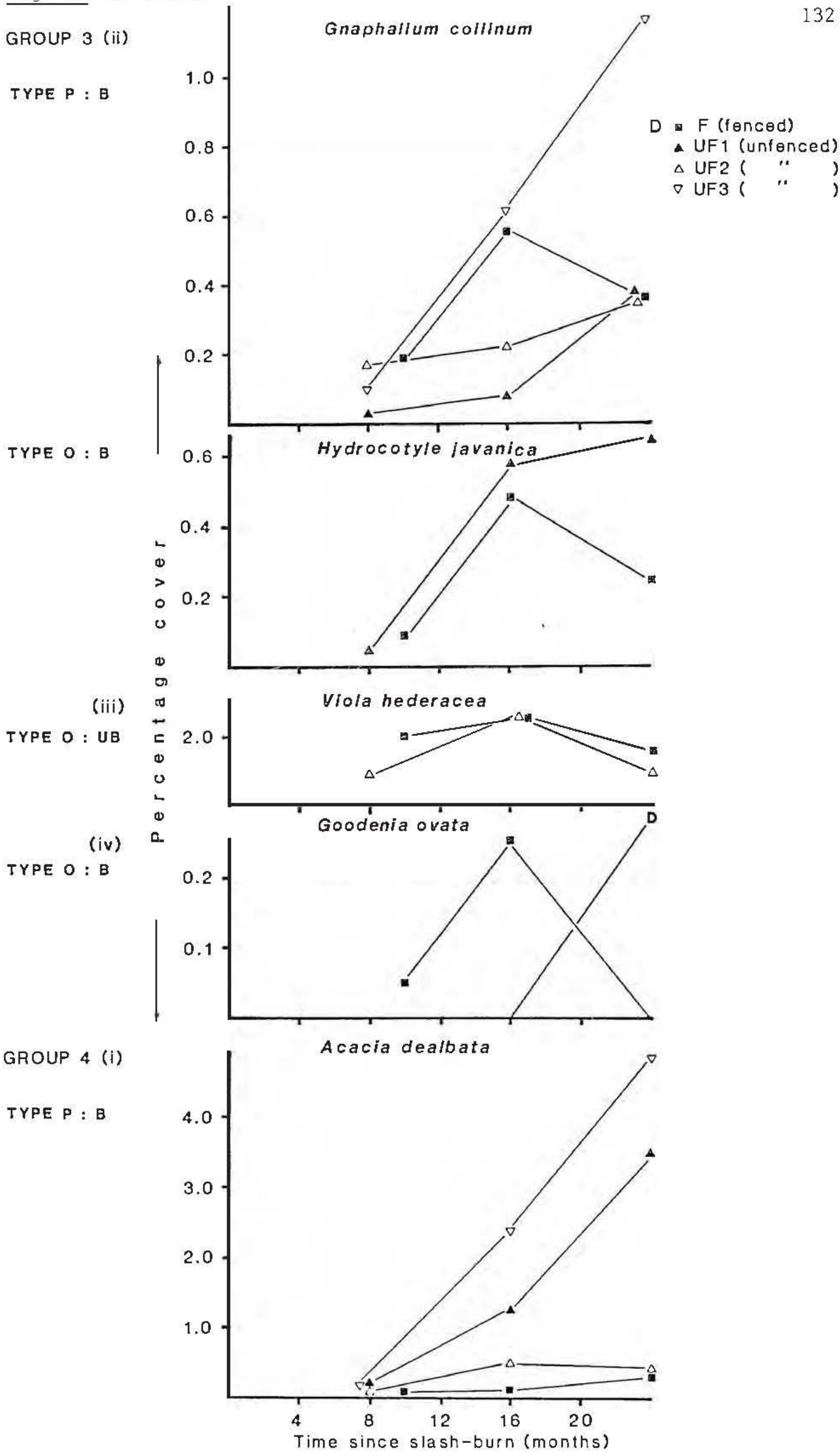


Fig. 18 (a) contd.



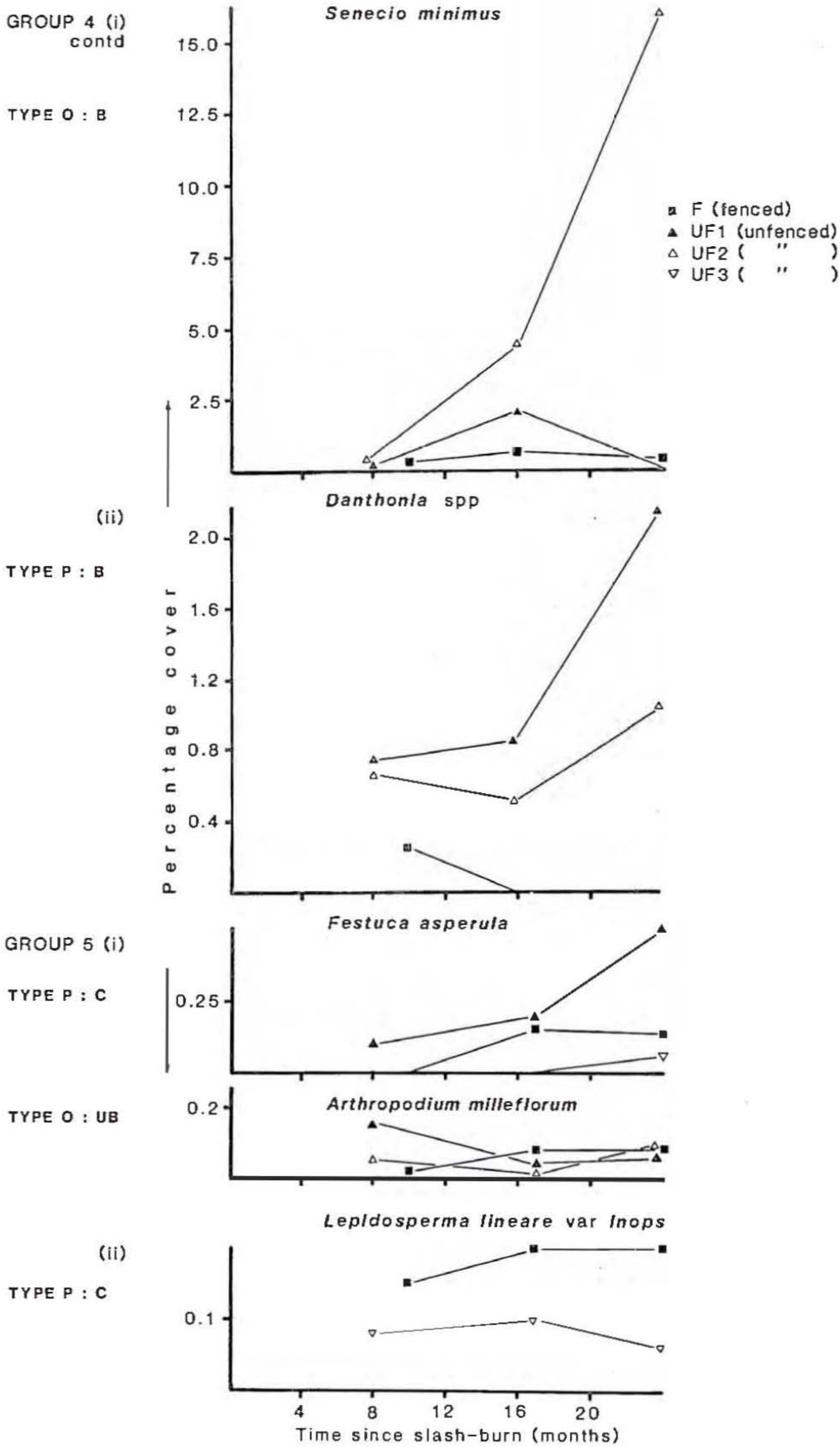

GROUP 4 (i) contd
TYPE O : B
Senecio minimus
15.0
12.5
10.0
7.5
5.0
2.5
F (fenced)
UF1 (unfenced)
UF2 (")
UF3 (")
(ii)
TYPE P : B
Danthonia spp
2.0
1.6
1.2
0.8
0.4
Percentage cover
GROUP 5 (i)
TYPE P : C
Festuca asperula
0.25
TYPE O : UB
Arthropodium milleflorum
0.2
Lepidosperma lineare var inops
(ii)
TYPE P : C
0.1
4
8
12
16
20
Time since slash-burn (months)

Fig. 18 (a) contd.

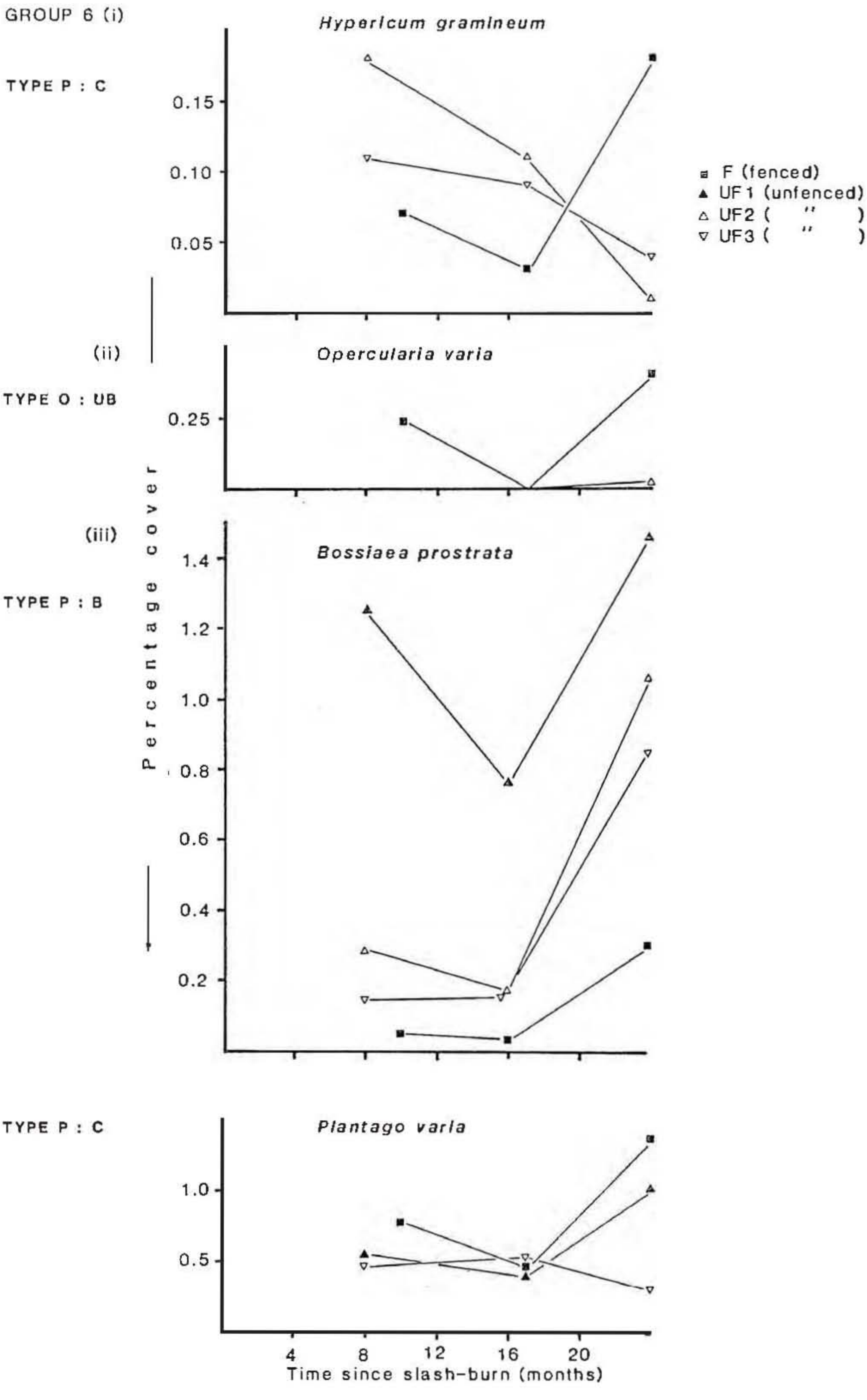
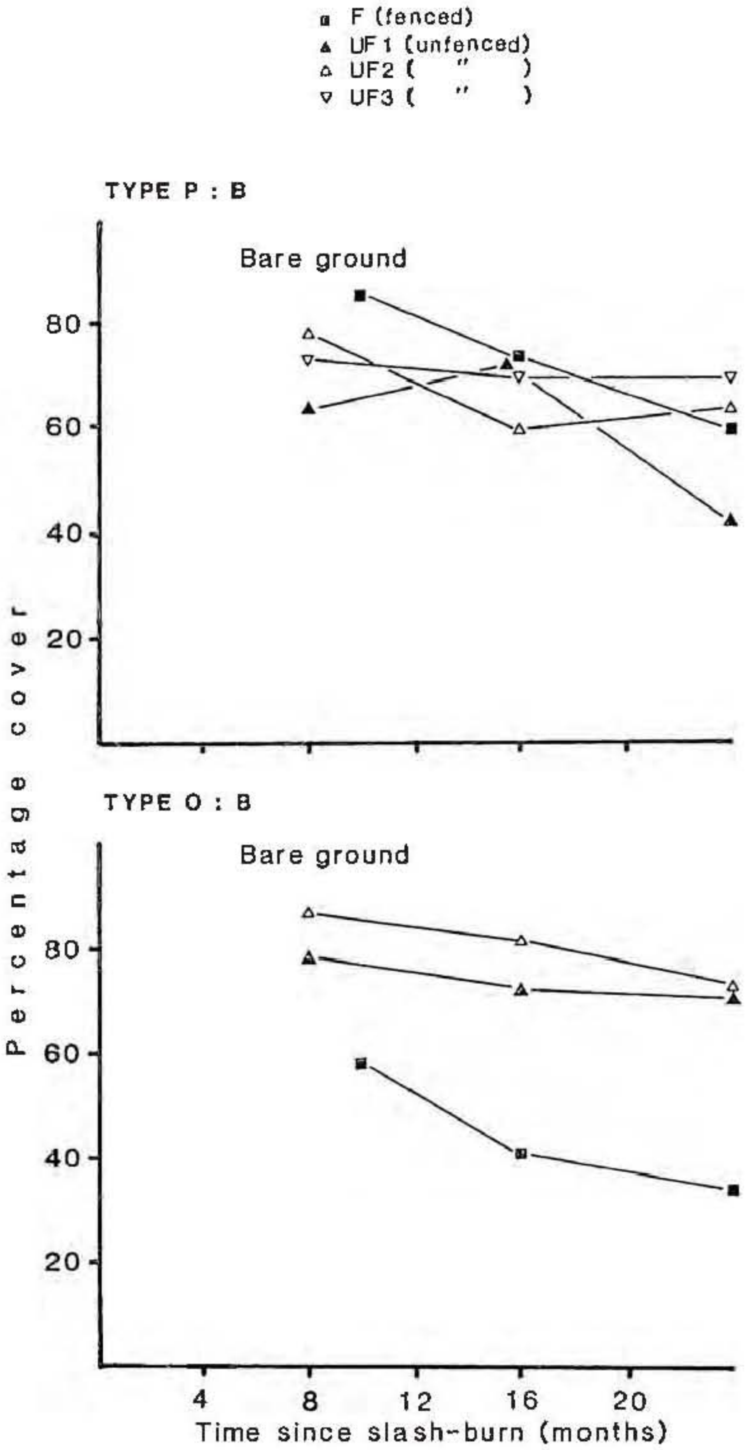


Fig. 18 (b)


F (fenced)
UF1 (unfenced)
UF2 (")
UF3 (")
TYPE P : B
Bare ground
80
60
40
20
Percentage cover
TYPE O : B
Bare ground
80
60
40
20
4
8
12
16
20
Time since slash-burn (months)

Individual plant species and their assigned growth response category according to vegetation type, treatment and control are synthesized in Table 10. Species varied markedly in their category of growth response on the two treatments and controls. A graph of percentage cover of bare ground occurring on the fenced and similar unfenced subplots on treatment B is shown in Fig. 18b. Bare ground decreased rapidly on the fenced plots in both vegetation types. In type O, the rate of decrease was greater on the fenced plot than on the similar unfenced subplots. In type P, the rate of decrease in the cover of bare ground varied between the unfenced subplots which were selected, however the decrease in cover was either less than, or equal to the cover decrease which occurred on the fenced plot.

Maximum heights of selected shrubs, graminoids and herbs in both fenced and unfenced areas on treatment B are presented in Table 11. In general, individuals flowered to a greater degree within the fenced areas (Plate 4). Grass species flowered more profusely in the exclosures, except in type P, 24 months after the slash-burn. However, in the latter case, heights of flowers were greater in the fenced area than in the unfenced (Plate 4). *Diplarrena moraea* and *Helichrysum scorpioides* flowered in the exclosure in type O after 24 months but not on the adjacent unfenced permanent plot. *Senecio minimus* did not differ greatly in height in type P between fenced and similar unfenced plots after 24 months. However, in type O the height of *S. minimus* was greater on the browsed and grazed areas.

3.4.2 Faecal pellet counts

Faecal pellets from four native animal species, and two introduced species were collected from the permanent quadrats during the course of the study (Table 12). The native species recorded were *Macropus rufogriseus* (Desmarest) (Bennett's wallaby, Red-necked wallaby or Brush wallaby), *Trichosurus vulpecula* (Kerr) (Common brushtail possum),

TABLE 10

Individual species and their growth response categories (see text) according to vegetation type, treatment and control.

	TYPE P			TYPE O		
	Treatment / control			Treatment / control		
	B Group	UB Group	C Group	B Group	UB Group	C Group
Species	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Acacia dealbata	- - - x - - -	- - - - - - -	- - - - - - x	- - - - - - -	- - - - - - -	- - - - - - -
Acacia stricta	- - - - - - -	- - - - - - x	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Acaena novae-zelandiae	- x - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Arthropodium milleflorum	- - - - - - -	- - - - - - -	- - - - - - x	- - x - - - -	- - - - x - -	- - - - - - -
Astroloma humifusum	- - - - - - -	- - - - - - -	- - - - x - -	- - - - - - -	- - - - - - -	- - - - - - -
Bossiaea prostrata	- - - - - x -	x - - - - - -	- x - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Coprosma quadrifida	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Danthonia spp.	- - - x - - -	- - - - - - -	x - - - - - -	- - - - - - -	x - - - - - -	- - - - - - x
Deyeuxia spp.	- - - x - - -	- - - - - - -	x - - - - - -	- - x - - - -	- - - - - - -	- - - - - - -
Diplarrena moraea	- - - - - - -	- - - - - - -	- - - - - - x	x - - - - - -	- - - - x - -	- - - - - - x
Drosera auriculata	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Epacris impressa	- - - - - - -	- - - - - - x	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Eucalyptus viminalis	x - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Festuca asperula	- - - - - - -	- - - - - - -	- - - - x - -	- - - - - - -	- - - - - - -	- - - - - - x
Galium albescens & G.australe	- - x - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Gnaphalium collinum	- - x - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Goodenia lanata	- - - - x - -	- - - - - - -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -
Haloragis tetragyna	- x - - - - -	- - - - - x -	- - - - - x -	- - - - - - -	- - - - - - -	- - - - - - -
Haloragis teucrioides	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Helichrysum scorpioides	- - - - - - -	- - - - - - -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -
Helichrysum thyrsoideum	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x
Hydrocotyle javanica	- - - - - - -	- - - - - - -	- - - - - - -	- - x - - - -	- - - - - - -	- - - - - - -
Hypericum gramineum	- - - - - - x	- - - - - - x	- - - - - x -	- - - - - - -	- - - - - - -	- - - - - - x
Hypochaeris radicata	- - - - - - -	- - - - - - -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -
Lagenophora stipitata	- - x - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - x -	- - - - - - x
Lepidosperma lineare var. inops	- - - - - - -	- - - - - - -	- - - - x - -	- - - - - - -	- - - - - - -	- - - - - - -
Leptorhyncos squamatus	- - - - - - -	- - x - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Leptospermum scoparium	- x - - - - -	- - - - - - -	- - - - - - x	- - - - - - -	- - - - - - -	- - - - - - x
Lissanthe strigosa	- - - - - - -	- - - - x - -	- x - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Lomandra longifolia	- - - x - - -	- - - - x - -	- - - - - - x	- - - - - - -	- - - - - - x	- - - - - - -
Lomatia tinctoria	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - x	- - - - - - x
Microlaena stipoides	- - - - - - -	- - x - - - -	- - - - - - -	- x - - - - -	- - - - - - -	x - - - - - -
Opercularia varia	- - x - - - -	- - - - - - -	- - - - - - -	- - x - - - -	- - - - - x -	- - - - - - -
Orchidaceae spp.	- - - - - - -	- - - - - - -	- - - - - - x	- - - - - - -	- - - - - - -	- - - - - - -
Oxalis corniculata	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Pentapogon/Dichelachne	x - - - - - -	- - - x - - -	- - - - - - -	- - x - - - -	- - - - - - -	- - - - - - -
Pimelea humilis	- - - - - - -	- - - - - - -	- x - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Plantago varia	- - - x - - -	- - - - - x -	- - - - - x -	- - - - - - -	- - - - - - -	- - - - - - -
Poa labillardieri	- - - - - - -	- - - - - - -	- - - - - - -	x - - - - - -	- - - x - - -	- - - - - - -
Poa labillardieri & P.rodwayi	- x - - - - -	- - x - - - -	- - - - x - -	- - - - - - -	- - - - - - -	- - - - - - -
Pteridium esculentum	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -	- - - - - x -
Pultenaea juniperina	- - - - - - -	- - - - - - -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - x
Schoenus apogon	x - - - - - -	- - - - - x -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -
Senecio minimus	- x - - - - -	- - - - - - -	- - - - - - -	- - - x - - -	- - - - - - -	- - - - - - -
Stipa pubinodis	- x - - - - -	- - - - - - -	x - - - - - -	- - - - - - -	- - - - - - -	- - - - - - -
Themeda australis	- - - - - - -	- - - - - - -	- - - x - - -	- - - - - - -	- - - - - - -	- - - - - - -
Viola hederacea	- - - - x - -	- - - - - x -	- - x - - - -	- x - - - - -	- - x - - - -	- - - - - - x
Wahlenbergia spp.	- - - - - - -	- - x - - - -	- - - - - - -	- - - - - - -	- - x - - - -	- - - - - - -

TABLE 11

Maximum height of selected species in the fenced plot (F) and similar unfenced subplots (UF) on treatment B. Figures in parentheses are the density of Gramineae inflorescences per m².

		Height (cm)			
		Time since slash-burn (months)			
		16		24	
Vegetation type	Species	F	UF	F	UF
P	*Acacia dealbata*	12	28	15	60
	Leptospermum scoparium	20	30	32	45
	Gramineae inflorescences	60 (50)	66 (15)	130 (50)	55 (60)
	Senecio minimus	34	18	110	115
O	*Diplarrena moraea*	21	12	25	25
	Gramineae inflorescences	70 (150)	40 (5)	100 (150)	40 (40)
	Pultenaea juniperina	30	<5	45	5
	Senecio minimus	17	35	40	115

Vombatus ursinus (Shaw) (Common wombat) and Perameles gunnii Gray (Eastern swamp rat). The introduced species were Oryctolagus cuniculus (L.) (European rabbit) which was introduced into Australia in the mid-nineteenth century, and Ovis aries (L.) (Domestic sheep).

In addition, faecal pellets of the carnivore Sarcophilus harrissi (Boitard) (Tasmanian devil) were observed on occasions at the junction of treatment B with uncut forest, and also on tracks within the coupe. Faecal pellets of another carnivore Dasyurus viverrinus (Shaw) (Native cat) were numerous particularly in the areas adjacent to creeks where thick vegetation provided plenty of cover. An individual of Tachyglossus aculeatus (Shaw) (Echidna) was also seen traversing Plot 2, type O, treatment UB. T. aculeatus was also observed close to type P plots on treatment UB on a separate occasion. The partial skeletons of one individual of Pseudocheirus peregrinus (Boddaert) (Common ringtail possum) and one of Trichosurus vulpecula together with a large amount of nesting material, were found inside a hollowed specimen of Eucalyptus obliqua in the type P control area (D. Peters, personal communication).

The number of pellets cleared from treatment B quadrats, 4 months after the slash-burn, was greater in type P than in type O (chi-squared: $p = 0.001$; Table 12). Macropus rufogriseus pellets dominated in both instances.

The number of pellets cleared initially from treatment UB and the control plots were also greater in type P than in type O (chi-squared: $p = 0.001$). Since these sites were not burnt there was no indication of the time period over which the pellets had been deposited. Decomposition of pellets is likely to have been greater on the relatively moist sites in type O, than on the drier localities in type P. Macropus rufogriseus pellets were the most numerous.

The mean monthly deposition of M. rufogriseus pellets on treatment B, type O plots was 14 (0-4 months after the slash-burn), 43 (4-8 months), 53 (8-16 months) and 57 (16-24 months). Similar figures for

TABLE 12

Number of faecal pellets according to mammal species, collected through time from the permanent plots in each vegetation type, treatment and control.

† = initial count (deposited over unknown time period).

NA: data not available

Time since slash-burn (months)

Vegetation type	Treatment/ control	4		8		16/17		24	
		No. of pellets	Species	No. of pellets	Species	No. of pellets	Species	No. of pellets	Species
P	B	159	Macropus rufogriseus	119	M. rufogriseus	273	M. rufogriseus	287	M. rufogriseus
		-	-	-	-	1	Trichosurus vulpecula	8	T. vulpecula
		-	-	-	-	-	-	4	Oryctolagus cuniculus
	UB	NA	-	†565	M. rufogriseus	279	M. rufogriseus	131	M. rufogriseus
		-	-	†19	T. vulpecula	5	T. vulpecula	2	T. vulpecula
		-	-	†9	Vombatus ursinus	-	-	-	-
		-	-	-	-	8	Perameles gunnii	-	-
	C	NA	-	†121	M. rufogriseus	73	M. rufogriseus	79	M. rufogriseus
		-	-	†1	T. vulpecula	43	T. vulpecula	15	T. vulpecula
		-	-	†3	P. gunnii	-	-	-	-
		-	-	†11	Ovis aries	-	-	-	-
O	B	57	M. rufogriseus	171	M. rufogriseus	425	M. rufogriseus	459	M. rufogriseus
		1	T.vulpecula	-	-	5	T. vulpecula	14	T. vulpecula
		-	-	6	O. cuniculus	32	O. cuniculus	53	O. cuniculus
		-	-	1	V. ursinus	-	-	-	-
	UB	†70	M. rufogriseus	137	M. rufogriseus	167	M. rufogriseus	72	M. rufogriseus
		-	-	-	-	3	T. vulpecula	5	T. vulpecula
		-	-	1	V. ursinus	10	V. ursinus	1	V. ursinus
	C	†2	M. rufogriseus	-	-	26	M. rufogriseus	15	M. rufogriseus
		-	-	-	-	1	T. vulpecula	1	T. vulpecula

type P, treatment B, were 40 (0-4 months), 30 (4-8 months), 34 (8-16 months) and 36 (16-24 months).

Overall, during the periods 8-16 months and 16-24 months after the time of the slash-burn, the greatest number of faecal pellets was deposited on treatment B, type O plots (chi-squared: $p = 0.001$). The least numbers of pellets collected in both vegetation types were from the control plots (chi-squared: $p = 0.001$).

Defaecation by Oryctolagus cuniculus was recorded only on treatment B plots, and the numbers of pellets were low compared to those of M. rufogriseus. O. cuniculus pellets were more numerous in type O than in type P, and their number increased through time. Trichosurus vulpecula pellets occurred in each vegetation type, treatment and control, though numbers remained low throughout. Defaecation by Vombatus ursinus was most common on treatment UB plots. Faecal deposition by V. ursinus is thought to demarcate feeding territory boundaries (Triggs, 1984). Ovis aries pellets were found on one control plot in type P. The pellets could have been up to 10 years old (R. Mawbey, personal communication).

3.5 DISCUSSION

The important effect on plant growth of browsing and grazing by wallabies has been noted by Cremer (1960), Mollison (1960), Gilbert (1961) and Cremer (1969) in Eucalyptus regnans regrowth, (Statham 1983) in E. delegatensis regeneration, Floyd (1980) in variously aged E. grandis plantations, and Leigh and Holgate (1979) in dry sclerophyll forest and woodland.

At MM14 the growth response of individual plant species following protection from browsing and grazing varied between vegetation types, treatments and controls (section 3.4.1; Table 10). Increased growth after exclosure was most marked on treatment B, particularly in type O (group 1: section 3.4.1; Plate 4). In general, herbs, grasses and graminoids, together with certain shrub species, were grazed preferentially.

Following fire, grazing maintained plants in the early stages of their life cycle, with shoots and suckers remaining relatively soft, lush and extremely palatable compared to adult foliage. Exclosure allowed certain heavily grazed species to change from a palatable to non-palatable phenology. For example, the first shoots of Pultenaea juniperina were repeatedly grazed to ground level in the unfenced areas. However, once protected, the species grew rapidly, developing hard, thorny leaves. In certain cases elsewhere on treatment B, sufficient protection was afforded by logs which allowed the shrub to develop. Changes in palatability following the removal of grazing has also been noted by Harper (1977) in relation to grass species.

Mooney and Dunn (1970) have described post-fire grazing as a powerful selective agent favouring species and biotypes which rapidly develop physiologically unattractive attributes, such as hard, thorny or distasteful leaves and twigs. In addition, those species with the highest vegetative regeneration capacities may out-compete others less capable of overcoming damage.

Grazing of the rapidly growing graminoids, Gahnia grandis and Lomandra longifolia was negligible. In contrast, Diplarrena moraea, which is known to grow rapidly following fire elsewhere in southeastern Tasmania, was severely affected by grazing, particularly in type O plots. The cover of this species was progressively reduced (section 2.5.2.5) and reproductive ability impaired (section 3.4.1).

Increased seed set of grass species following protection was particularly evident in type P, treatment B. Success was most noticeable 24 months after the slash-burn with inflorescences exceeding 1m in height (Table 11; Plate 4).

Stomach content analyses of individuals of Macropus rufogriseus, have shown that their diet consists of a wide variety of monocotyledons and dicotyledons (Statham, 1983). Grasses constituted 50% of all the samples that were tested, whereas very few eucalypt fragments were found. Trichosurus vulpecula showed a preference for soft leaved dicotyledons, including eucalypts. However, Radwan (1974) noted that preferential grazing of plant species and certain plant parts usually changes with the age and physiology of the animal. Moreover, the plants eaten may differ between, and within localities during different seasons and after habitat modifications.

At MM14 certain plants thrived despite grazing pressure (group 2: section 3.4.1). Species of prostrate growth habit were particularly successful. For instance, Acaena novae-zelandiae had abundant lateral shoot growth in type P, treatment B. A. novae-zelandiae showed no evidence of grazing by mammals, although T. vulpecula has been found to eat members of the genus Acaena (Statham, 1983). However, localized swarms of Haltica sp. (Metallic flea beetle) were seen feeding on A. novae-zelandiae in September 1984, outside the treatment B permanent plots.

The highly palatable grass, Microlaena stipoides, appeared to be stimulated by grazing following fire in type O (group 2(ii): section 3.4.1). With the abundance of bare ground the species spread laterally. Interestingly, on treatment UB and the control plot, M. stipoides grew vertically rather than horizontally. A similar response to defoliation has been described by Grime (1979) in the grass, Agrostis tenuis. Abundant lateral shoot growth and tillering in species related to those occurring at MM14, have also been noted by Selkirk et al. (1983) on subantarctic Macquarie Island as a response to grazing by Oryctolagus cuniculus. In the present study, the numbers of pellets deposited by O. cuniculus on the permanent plots were low compared to the numbers deposited by Macropus rufogriseus. Nevertheless, squats consisting of large numbers of O. cuniculus pellets, became progressively more numerous outside the permanent plots on treatment B. There was a notable absence of pellets of this species on treatment UB. Although few individuals, or burrows of O. cuniculus were seen at MM14, the amount of defaecation implied that grazing by this species was significant on treatment B. In areas of sufficient surface cover very few burrows are dug, and most rabbits live under logs or in scrub (Taylor, 1956).

Some plant species at MM14 were outcompeted immediately following fencing, and thus disappeared (group 4(ii): section 3.4.1), whereas others responded to protection by initial rapid growth followed by a decline (group 3: section 3.4.1). The latter species, whilst palatable, appeared competitively inferior in the absence of grazing, compared to other species with more persistent and sustained growth (e.g. group 1: section 3.4.1).

Certain plants increased in cover after fencing (group 5: section 3.4.1) but were sufficiently competitive to prevent the demise suffered by group 3 species. The pattern of decline then increase in growth after exclosure shown by group 6 species may also be attributable to interspecific and intraspecific competition. However, it is likely that species in group 6(iii) were responding to seasonal fluctuation.

Species and individuals on the treatment UB and control plots were mostly less responsive to protection by fencing than those on treatment B. Species that did benefit from exclosure on treatment UB and the control C were generally grasses and herbs. Similar growth responses of these lifeforms following the removal of grazing in unburnt vegetation have been noted by other workers (e.g. Drew, 1947; Carr and Turner, 1959; Selkirk et al., 1983).

Although grazing by invertebrates was not measured directly in the present study, insect galls were recorded on Acacia stricta in the type O control plots (section 2.6.4). In addition, the butterfly

Heteronympha merope (Fabricius) was seen taking nectar from flowers of Leptospermum scoparium in January 1984 on the same plots. Species of Lepidoptera are known to predate eucalypts (Ohmart et al., 1983). However, although some eucalypt predation by Lepidoptera was evident at MM14, none were actually observed grazing. Species of Lepidoptera recorded at MM14 during the summer of 1983/4 are listed in Appendix 5.

The results from MM14 can be compared to the data obtained by Leigh and Holgate (1979) from a site in dry sclerophyll vegetation where Macropus rufogriseus was the dominant herbivore. They compared burnt and unburnt vegetation, with and without the presence of grazing. It was found that grazing after burning led to substantial mortalities of trees and shrubs, and that regrowth height was kept at <10cm for at least 14 months after the fire. In contrast, shrubs reached a height of 54cm in the ungrazed, burnt treatment. Poa sieberana, the only grass species present in any quantity, was repeatedly grazed to near ground level, whereas unburnt tussocks were largely ignored.

With the exception of substantial mortalities of trees and shrubs, the data from the present study support the findings of Leigh and Holgate (1979). At MM14 the size of the fenced plots was insufficient to report on tree and shrub mortalities compared to similar unfenced areas. Grazing, particularly of certain species following fire, does profoundly affect community species composition and relative abundance. In addition, structural attributes such as height and species density, together with reproductive ability may be severely impaired as a result of selective predation.

The present study supports the hypothesis that slash-burning encourages grazing and browsing in clearfelled dry forests. However, the impact varies between forest types. Type O forest appears to sustain a greater degree of post-fire predation than type P forest.

Grazing and browsing affects the relative abundance of plant species, with unpalatable vegetative reproducers often achieving early post-fire dominance. However, overall, predation does not appear to alter floristic composition except in localised areas.

CHAPTER 4

FUEL DYNAMICS FOLLOWING CLEARFELLING

4.1 INTRODUCTION

Jacobs (1955) described slash and undergrowth left following clearfelling as presenting two basically different problems in forestry. Firstly, site deterioration and damage to advanced natural regeneration could be caused by their removal (see Chapter 1). Secondly, dangers could accompany their retention, mainly through the fire hazard posed by the slash to the regenerating stand and to adjacent unlogged forest.

In discussing the combustion of forest fuels, Byram (1959) arbitrarily classified them into available and non-available categories. The former category largely corresponded to the dead and cured material which is actually consumed in a fire, the components of which can vary widely in their moisture content, whilst the latter category encompassed living fuels. The production of slash increases the available fuel load on the forest floor. In addition, increased insolation following clearfelling can induce greater moisture loss from fuels, resulting in drying out of material and consequent increased rate of flame front spread should a fire start (Brown and Davis, 1973).

Fuel load, fuel size, fuel structure and fuel composition together with their effects on fire hazard in slashed environments have been the most extensively studied in the United States (e.g. Childs, 1939; Fahnestock, 1960; Fahnestock and Dieterich, 1962; Wagener and Offord, 1972; McNab et al., 1978). The physical characteristics of the fuel, such as the surface-area-to-volume ratio of particles, the degree of aeration within the fuel bed, the vertical and horizontal continuity of the fuels, and variations in moisture content, have been the bases for both field assessment of slash material and experimental modelling of fire behaviour (e.g. Fons, 1946; Anderson, 1969; Fahnestock, 1970; Brown, 1972; Rothermel, 1972; Frandsen and Schuette, 1978; Frandsen and Andrews, 1979).

In an Australian context, studies have largely concentrated on the accumulation and moisture content of fuels, and their relationship to fire hazard in uncut forests (e.g. McArthur, 1962; Peet, 1965; Hatch, 1969; Peet, 1971; Sneeuwjagt, 1973; Van Loon, 1977; Raison et al., 1983). There are few data on fuel loads, fuel components and fuel characteristics following clearfelling. This dearth of knowledge regarding fuel dynamics after forest utilization in dry sclerophyll forest has been noted by Bowman and Jackson (1981) and by Jackson and Bowman (1982).

This chapter seeks to establish whether slash-burning significantly reduces the fire hazard on a clearfelled site compared to an equivalent unburnt site over time. Fire hazard is examined in terms of the load, arrangement, structure and composition of fuels left as a result of clearfelling in dry forests.

4.2 METHODS

4.2.1 Fuel sampling

4.2.1.1 Sites

Fuel sampling was undertaken on treatments B and UB at MM14 during April 1982, April 1983 and April 1984. Sampling quadrats were located at each of the random points used in the floristic survey described in Chapter 2, section 2.3.1 (Fig. 12).

In addition, sampling was carried out in the summer of 1982/83 at each of the four coupes described in Chapter 2, section 2.3.6 (namely MM20, TO2, TO30, and TO56). Quadrats were positioned at each of the random points used in the point-centre quarter method (section 2.3.6; Figs. 7-10).

4.2.1.2 Procedure

Sampling methodology was adapted from the planar intersect method outlined by Brown (1970b, 1971) and the collection techniques of McNab et al. (1978). Quadrats, 0.25m x 1.0m, were positioned at the random points so that their longest side was in the direction of the slope. Each plot was demarcated using nails, flagging tape and one metre poles. At MM14, April 1982, quadrats were located 0.5m from the bottom right corner of the floristically surveyed, 5m x 5m plot (Fig. 19a). In 1983 and 1984, fuel sampling quadrats were moved one metre to the right of, and parallel to the previously sampled plots (Fig. 19a). Thus quadrats were placed in a range of fuel loads and arrangements in each year of sampling. Examples of the fuel loads and quadrat sampling undertaken are shown in Plate 5.

4.2.1.3 Fine fuel (hereafter taken as all material <2.0cm in diameter or thickness)

The maximum heights of elevated above-ground live material (A/GL) and above-ground dead material (A/GD) were measured for each quadrat. In addition, the average depth of live and dead ground material (GL or GD) was also noted. Ground material included the basal shoots of certain species, for example *Gahnia grandis*. The distinction between elevated and ground material was made by visual assessment of degree of compaction. Material assigned to the latter category occurred in contact with the ground, in a close arrangement with little or no aeration.

The fine fuel content of each quadrat was collected to a height of 1.5m only. Material was removed using secateurs, a hacksaw or a trowel and placed in heavy duty paper bags according to the categories A/GL, A/GD, GL and GD.

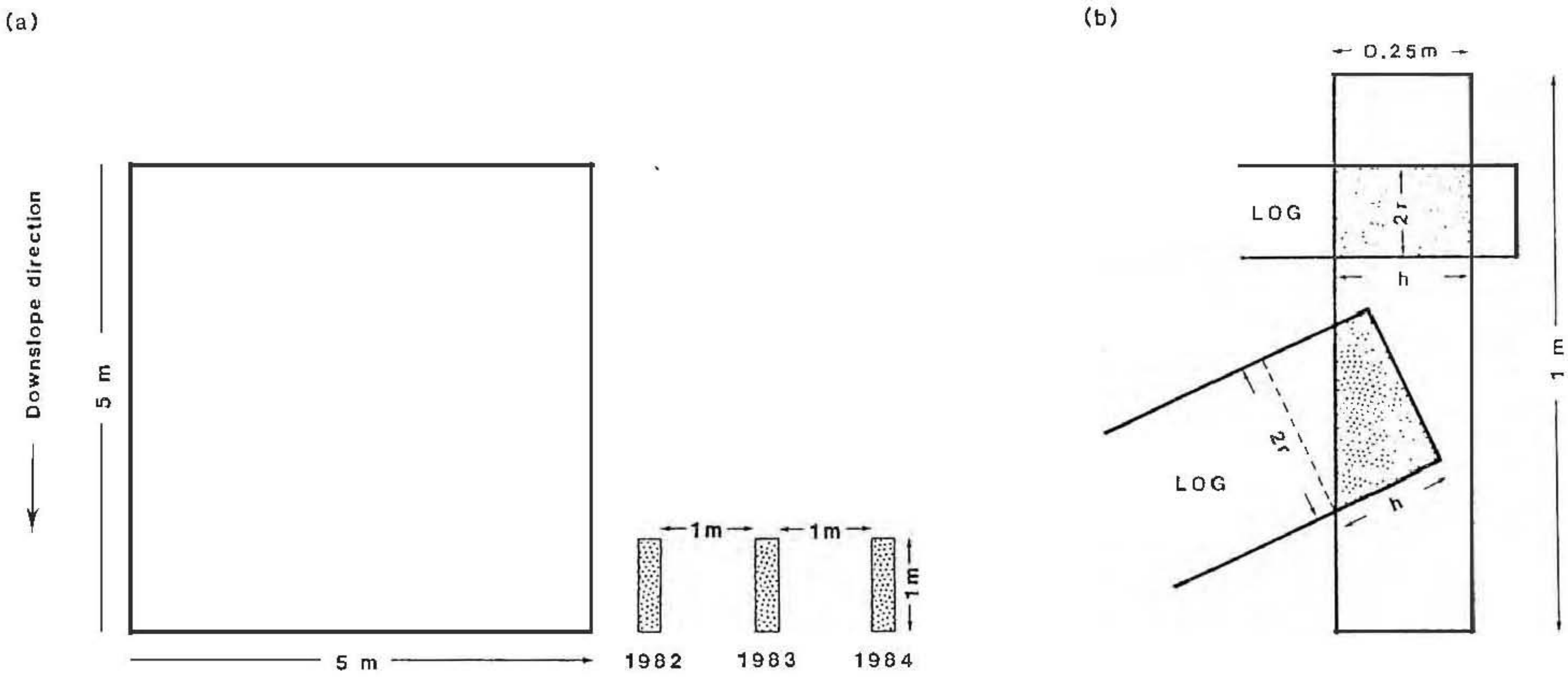


Fig. 19 : (a) The location of the fuel quadrats in 1982, 1983, and 1984 relative to each of the 5m x 5m quadrats sampled during the floristic survey (section 2.3.1).

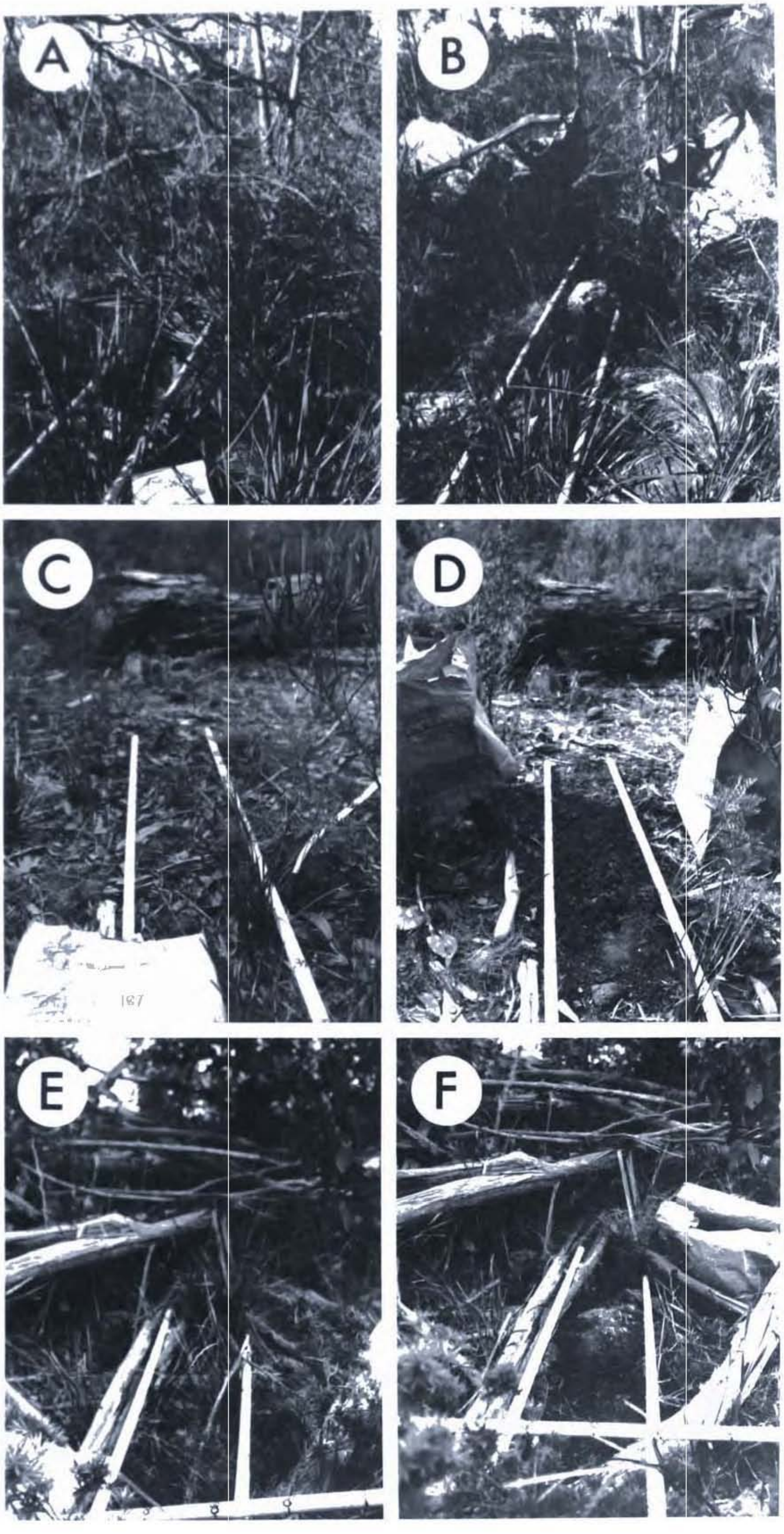
(b) Diagrammatic representation of the 0.25m x 1m fuel quadrat. Shaded areas depict the portion of the logs which were included in the measurement of coarse fuel. For explanation of the calculation of their volume see section 4.2.1.4.

h = length of log inside quadrat; 2r = diameter of log.

Plate 5 :

Examples of the varying levels and structures of fuel in which sampling quadrats were placed. Fine fuels were removed from within the 0.25m x 1m quadrats, which were placed in a variety of fuel arrangements and fuel structures during the recording undertaken in 1982, 1983 and 1984. The dimensions of coarse fuels were recorded and used in subsequent calculations of volume (section 4.2.1.4). The heights of live and dead material which overtopped the quadrat were measured prior to the destructive sampling.

(A), (B); (C), (D); (E), (F) depict quadrats before and after sampling.


A
B
C
D
E
F

All samples were returned to the laboratory where they were oven-dried at 105°C. Above-ground live material (A/GL) and live ground material (GL) were weighed. Elevated dead material and ground dead material were sorted into 9 components: leaves; twigs <0.5cm, 0.5-1.0cm, 1.0-1.5cm and 1.5-2.0cm in diameter or thickness; bark; other dead vegetation consisting of the leaves, culms, inflorescences, fronds and foliage of herbs, graminoids, grasses and ferns (hereafter referred to as herbaceous vegetation); exposed lignotuber; miscellaneous fine material. The last component was obtained by sieving finely divided material to remove as much soil and charcoal contamination as possible. All sorted components were weighed.

4.2.1.4 Coarse fuel (hereafter taken as all material ⩾2.0cm in diameter or thickness

Coarse fuel was recorded in two categories; above-ground level (A/GD) and ground level (GD), which were later combined to give the total of elevated and ground material (TOTAL). All material was assessed by volume. Very irregular pieces of wood were recorded according to average length, thickness and width. However, most logs and limbs were approximately cylindrical, therefore volume was calculated using the formula $V = \pi r^2 h$, where V = volume, r = radius and h = length of the log or limb inside the quadrat. Some modification was required where the logs crossed the quadrats obliquely. In these instances, length and diameter measurements were taken as shown in Figure 19b, then the total volume of the hypothetical cylinder was calculated, and the proportion of that volume within the quadrat estimated.

4.3 DATA EXTRACTION AND ANALYSIS

4.3.1 Fine fuel within vegetation types P and O, and within type D/O, on burnt and unburnt treatments

Due to the marked and very variable skewed nature of the data, nonparametric statistical methods were used. Each fuel component was tested using the Kruskal-Wallis (K-W) one-way analysis of variance performed by the computer package SPSS (Nie et al., 1975; Hull and Nie, 1981). Analysis showed that three fuel components (elevated miscellaneous fine material, elevated lignotuber and exposed ground lignotuber) did not differ ($p = 0.05$) between any of the treatments or regrowth ages sampled within vegetation types P and O, or within type D/O. Thus these three components were excluded from subsequent analysis.

The weights of individual fuel components were compared between treatments and ages of regeneration within vegetation types P and O, and within type D/O, using the Mann-Whitney U Test. Due to the size of the data set, large numbers of comparisons were necessary. Consequently, high confidence limits were set. Three levels of significance were accepted, $p = 0.02$, $p = 0.01$ and $p = 0.001$. Probabilities of $p = 0.05$ were recorded as weak differences only.

4.3.2 Coarse fuel within vegetation types P and O, and within type D/O, on burnt and unburnt treatments

Volumes of material in the three categories recorded (section 4.2.1.4) within vegetation types P and O, and within type D/O were compared using the K-W analysis of variance. Significant differences were accepted at the same probability levels as for fine fuel (section 4.3.1).

4.3.3 Fuel left following clearfelling without slash-burning within vegetation types P and O

4.3.3.1 Weight of fine fuel

The total weights of dead material occurring in individual quadrats on treatment UB, MM14, were compared between each year of sampling using the K-W test. There was no significant difference between totals in the different ages of regeneration at $p = 0.05$, so results from the three years of sampling were pooled. The running mean of the resulting 146 quadrats was plotted (Fig. 20a). After initial marked fluctuation, the running mean stabilised after the results from approximately 125 quadrats had been amalgamated. Consequently, the average weight of fine fuel, calculated from all 146 quadrats, was taken as a fair representation of the absolute fine fuel loads over the entire coupe, and the mean weight per quadrat ($0.25\ m^2$) was expressed as tonnes per hectare.

4.3.3.2 Volume of coarse fuel

Data from treatment UB, MM14, were compared between the three ages of regeneration using the K-W test. There was no significant difference between ages at $p = 0.05$. The running mean was calculated as described in section 4.3.3.1 and plotted (Fig. 20b). The mean volume per $0.25m^2$ was obtained for all the quadrats on treatment UB, and expresed as m^3 per hectare.

4.3.4 Height/depth of live and dead fine fuel

The maximum heights of elevated live, and elevated dead fuel recorded in the quadrats sampled in the individual treatments, vegetation types and regrowth ages were assigned to 20cm height classes. Depths of ground material from each plot were allocated to 5cm classes.

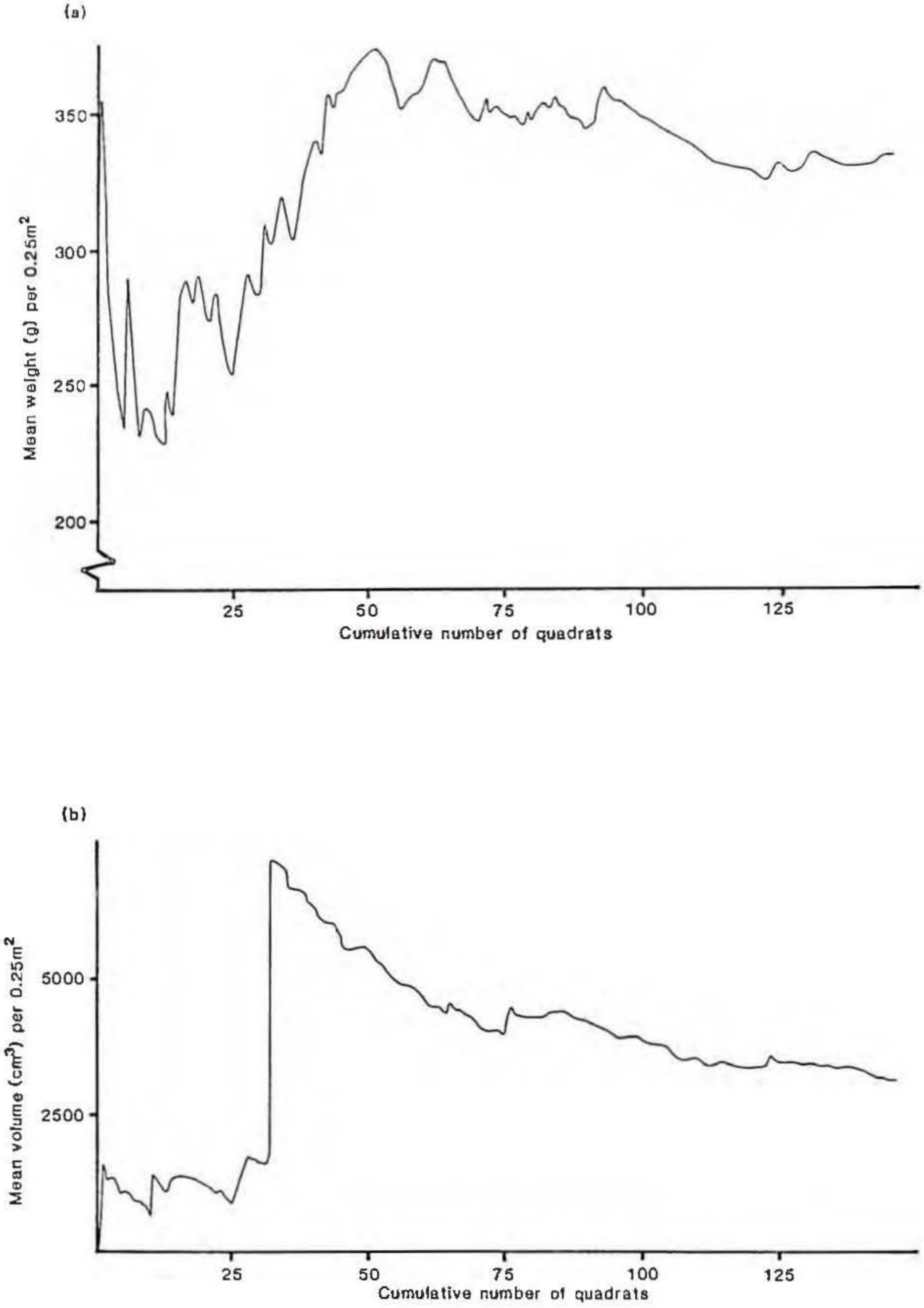


Fig. 20 : (a) Running mean of the weights (g) of fine dead fuel, (b) running mean of the volume (cm^3) of coarse dead fuel, collected from each of the fuel quadrats on treatment UB, MM14 during the sampling periods in 1982, 1983 and 1984.

4.4 RESULTS

4.4.1 Fine fuel within vegetation types P and O

4.4.1.1 Comparison between vegetation types for the same age of regeneration (Table 13A)

(1) Burnt treatments

There was no significant difference in the weights of above-ground live material (A/GL) between types P and O at age zero. However, type O exceeded type P ($p = 0.001$) for A/GL after one year. The disparity between the two vegetation types was less pronounced at age two ($p = 0.05$) whilst type O had significantly greater elevated material at age five ($p = 0.001$). No significant difference was apparent between types P and O in the 9 year-old regeneration.

There was no significant difference between the two vegetation types in levels of live ground material (GL) for all ages of regrowth. The components of elevated dead material were generally not significantly different between types P and O, or only weakly so ($p = 0.05$). The weights of twigs (AT2 and AT3) were higher in type O than in type P at age zero but did not differ between vegetation types in older ages of regeneration. Type O, MM20, had significantly greater weights of elevated dead leaves than did type P ($p = 0.001$).

Rapid growth of *Pteridium esculentum* contributed to the significantly greater values of dead ground vegetation (GDV) in type O in the 1 year-old regeneration ($p = 0.01$). Fallen bark (GB) was greater in type P than in type O in the 1, 2 and 5 year-old regeneration, due to decorticating gum bark peeling from the remaining standing trees or from partially burnt slash.

The total weight of above-ground dead fuel (AGDT) and the total weight of dead ground material (GDT) did not differ significantly between types P and O for all ages of regeneration. AGDT was only weakly greater ($p = 0.05$) in type O than in type P in the 5 year-old regeneration.

(2) Treatment UB, MM14

Total above-ground dead fuel (AGDT) did not differ between types P and O at $p = 0.02$ for the three regrowth ages. AGDT in type O was only weakly in excess of that in type P ($p = 0.05$) in the youngest regeneration. All above-ground live and dead components showed no significant difference between the two vegetation types at $p = 0.02$, with the exception of dead leaves (ALE) in the regeneration age zero and dead herbaceous vegetation (ADV), in the 1 year-old regrowth. Both fuel components were significantly greater in type O than in type P ($p = 0.01$).

Various ground fuel components were significantly greater in type O than in type P in the youngest regeneration (e.g. dead herbaceous vegetation, GDV; and twigs 1.5-2.0cm in diameter, GT4). Total ground material (GDT) did not differ between the two types at age zero or age one, but was significantly less in type P than in type O in the two year-old regrowth ($p = 0.01$). Of the separate fuel components sampled at age two, only twigs <0.5cm in diameter (GT1) showed any significant difference (type O > type P at $p = 0.01$).

4.4.1.2 Comparison of fuel components between treatments B and UB for the same vegetation type and age of regeneration Table 13B)

(1) Type P

Elevated live material (A/GL) was significantly greater on treatment UB compared to treatment B in regrowth aged zero and one at $p = 0.001$

and p = 0.01 respectively. However, there was no significant difference between treatments at p = 0.05 in the 2 year-old regeneration. Live ground material (GL) was significantly less on treatment B than on treatment UB (p = 0.001) at the first sampling period only.

In general, elevated dead fuel components did not differ between treatments in all ages of regeneration at p = 0.02. Twigs <0.5cm and 0.5-1.0cm in diameter (AT1 and AT2) were significantly less on treatment B than on UB at age zero only at p = 0.02 and p = 0.01 respectively.

Most ground fuel components were significantly less on treatment B than on treatment UB in all three ages of regeneration. Twigs 1.5-2.0cm in diameter (GT4) showed no difference throughout (p = 0.05) whilst twigs 1.0-1.5cm (GT3) did not differ between treatments in the 2 year-old regrowth at p = 0.05. Fallen bark (GB) was less on treatment B at age zero than on treatment UB (p = 0.001) but did not differ between treatments by age one at p = 0.05.

(2) Type 0

The categories of live material, A/GL and GL, were significantly greater on treatment UB than on treatment B at age zero only (p = 0.001). Similarly, the above-ground dead components of herbaceous vegetation (ADV), leaves (ALE), twigs <0.5cm in diameter (AT1), bark (AB) and the combined total (AGDT) were significantly less (p = 0.02) on treatment B than on treatment UB at first sampling. However, by age two only the component AT1 differed significantly at p = 0.02.

With the exception of twigs 1.5-2.0cm in diameter (GT4), all dead ground fuel components were consistently less (p = 0.02) on treatment B than on treatment UB in all regrowth ages. GT4 was significantly less at age zero only (p = 0.01).

4.4.1.3 Comparison of fuel components between ages of regeneration for the same treatment and vegetation type (Table 13C)

(1) Type P: treatment B.

The weight of above-ground live material (A/GL) increased from age zero to age five, but there was no significant difference (p = 0.05) between ages five and nine. The level of live ground material (GL) was greater in the age one regrowth than in the age zero (p = 0.001) but did not differ between ages one and two (p = 0.05). GL was significantly greater at age five than at either age two or age nine (p = 0.001).

Total above-ground dead material (AGDT) did not differ at p = 0.02 between successive ages of regeneration. The above-ground dead components, vegetation (ADV), twigs 0.5-1.0cm in diameter and twigs 1.0-1.5cm in diameter (AT2 and AT3) were greater in the 1 year-old regrowth than at age zero at p = 0.02. ADV was the only elevated dead component significantly greater at age two than at age one (p = 0.02). Only weak differences were apparent between any of the elevated dead components of the 5 and 9 year-old regeneration.

Dead ground fuel components generally showed no significant difference from one age of regeneration to the next. However, levels of dead vegetation (GDV) were greater in age five than in age two regrowth (p = 0.001). In addition, twigs 0.5-1.0cm in diameter (GT2) were greater in 5 year-old regrowth than in 9 year-old regeneration (p = 0.01) whilst leaves were greater in the latter than in the former (p = 0.01).

(2) Type O: treatment B

There was rapid growth of live material (A/GL and GL) at MM14 between ages zero and one (p = 0.001). However, no significant difference was evident between ages one and two at p = 0.05. Levels of live material were greater at MM20 than in the 2 year-old regeneration

TABLE 13

Median values of weight (g) of individual fuel components, together with significance comparisons, sampled in various ages of regeneration, treatment and vegetation type. Figures are given to the nearest 0.1g. Dashes indicate absence of the particular component.

A/GL = elevated live material;		GL = live ground material;	
ADV = elevated dead herbaceous vegetation;		GDV = dead ground herbaceous vegetation;	
ALE = elevated dead leaves;		GLE = dead ground leaves;	
AT1 = elevated dead twigs < 0.5 cm diameter;		GT1 = dead ground twigs < 0.5 cm diameter;	
AT2 = elevated dead twigs 0.5 - 1.0 cm diameter;		GT2 = dead ground twigs 0.5 - 1.0 cm diameter;	
AT3 = elevated dead twigs 1.0 - 1.5 cm diameter;		GT3 = dead ground twigs 1.0 - 1.5 cm diameter;	
AT4 = elevated dead twigs 1.5 - 1.0 cm diameter;		GT4 = dead ground twigs 1.5 - 2.0 cm diameter;	
AB = elevated dead bark;		GB = dead ground bark;	
AGDT = combined total of elevated dead material;		GMF = miscellaneous fine ground material;	
		GDT = combined total of dead ground material	

* significant at level p = 0.02; ** significant at p = 0.01; *** significant at p = 0.001; † significant at p = 0.05 only

(A) Comparison of fuel components between vegetation types P and O for the same treatment and age of regeneration.

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GMF	GDT
MM14	0	B	P	0.0	0.4	0.0	0.4	0.1	0.1	-	-	0.2	1.0	0.2	2.8	9.1	4.0	0.0	0.2	0.7	3.1	41.9
			sig.level						**	*												
			O	0.7	0.6	0.1	0.1	0.1	0.2	0.2	-	0.0	4.1	0.4	4.6	3.6	2.6	0.0	0.2	0.4	0.3	30.0
	1	B	P	6.1	14.7	0.1	0.0	1.8	0.2	0.4	1.3	0.0	9.4	0.5	1.9	8.5	5.3	0.0	0.6	9.2	0.2	60.8
			sig.level	***				†						**						**	*	
			O	31.1	11.8	0.2	0.0	0.1	0.0	1.0	2.3	0.1	0.8	2.7	2.7	5.7	3.3	0.1	0.4	0.8	0.1	34.3
	2	B	P	11.7	16.3	0.5	0.0	0.1	0.4	1.3	-	0.0	6.2	2.1	1.5	9.1	5.8	3.2	0.6	7.3	0.0	53.8
			sig.level	†		†														***	†	
			O	47.1	11.4	3.4	0.0	0.0	0.1	0.8	2.0	0.0	11.7	2.2	1.6	6.6	4.6	0.0	0.3	0.9	0.1	41.9
MM20	5	B	P	52.5	34.6	1.9	0.0	0.1	0.1	-	-	0.0	5.0	16.5	1.3	9.3	14.2	0.1	0.1	5.5	0.1	79.2
			sig.level	***			***						†		***		**			**		
			O	109.6	34.9	4.4	0.3	0.4	0.2	0.3	-	0.0	15.4	12.0	14.3	6.1	2.2	1.8	0.7	0.7	0.1	67.6
TO2	9	B	P	40.1	17.2	4.8	0.0	0.0	0.0	0.1	-	0.1	13.3	17.5	9.2	7.9	0.0	0.0	0.3	1.8	0.0	92.6
			sig.level												*							
			O	66.4	17.6	28.9	0.0	0.0	0.8	0.8	-	0.1	34.9	45.6	4.7	0.3	5.0	0.1	0.7	1.4	0.1	80.5
MM14	adv (0)	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
			sig.level				**						†	**		†			*			
			O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
	adv (1)	UB	P	22.8	16.6	0.2	0.0	0.9	0.2	1.0	2.0	0.0	16.7	4.8	32.9	33.7	15.9	10.2	0.9	11.9	15.6	204.9
			sig.level			**																
			O	24.1	15.5	1.7	0.1	5.3	0.5	0.0	1.2	0.0	36.4	15.5	14.4	41.4	18.0	20.1	0.3	14.7	19.7	220.1
	adv (2)	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
			sig.level				†									**						**
			O	43.4	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6

TABLE 13 cont'd

(B) Comparison of fuel components between treatments B and UB for the same vegetation type (P or O) and age of regeneration.

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GMF	GDT
MM14	0	B	P	0.0	0.4	0.0	0.4	0.1	0.1	-	-	0.2	1.0	0.2	2.8	9.1	4.0	0.0	0.2	0.7	3.1	41.9
			sig.level	***	***			*	**	†				**	***	***	**	*		***	***	***
	adv (0)	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
	1	B	P	6.1	14.7	0.1	0.0	1.8	0.2	0.4	1.3	0.0	9.4	0.5	1.9	8.5	5.3	0.0	0.6	9.2	0.2	60.8
			sig.level	**										***	***	***	***	**			***	***
	adv (1)	UB	P	22.8	16.6	0.2	0.0	0.9	0.2	1.0	2.0	0.0	16.7	4.8	32.9	33.7	15.9	10.2	0.9	11.9	15.6	204.9
	2	B	P	11.7	16.3	0.5	0.0	0.1	0.4	1.3	-	0.0	6.2	2.1	1.5	9.1	5.8	3.2	0.6	7.3	0.0	53.8
			sig.level											***	**	†	**				***	**
	adv (2)	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
	0	B	O	0.7	0.6	0.1	0.1	0.1	0.2	0.2	-	0.0	4.1	0.4	4.6	3.6	2.6	0.0	0.2	0.4	0.3	30.0
			sig.level	***	***	***	***	*				***	**	***	***	***	***	***	**	***	**	***
	adv (0)	UB	O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
	1	B	O	31.1	11.8	0.2	0.0	0.1	0.0	1.0	2.3	0.1	0.8	2.7	2.7	5.7	3.3	0.1	0.4	0.8	0.1	34.3
			sig.level			*	***	***	†			***	***	**	**	***	***	***		***	***	***
	adv (1)	UB	O	24.1	15.5	1.7	0.1	5.3	0.5	0.0	1.2	0.0	36.4	15.5	14.4	41.4	18.0	20.1	0.3	14.7	19.7	220.1
	2	B	O	47.1	11.4	3.4	0.0	0.0	0.1	0.8	2.0	0.0	11.7	2.2	1.6	6.6	4.6	0.0	0.3	0.9	0.1	41.9
			sig.level				†	*						**	***	***	***	***		***	***	***
	adv (2)	UB	O	43.3	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6

(C) Comparison of fuel components between ages of regeneration for the same treatment and vegetation type (P or O).

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GMF	GDT
MM14	0	B	P	0.0	0.4	0.0	0.4	0.1	0.1	-	-	0.2	1.0	0.2	2.8	9.1	4.0	0.0	0.2	0.7	3.1	41.9
			sig.level	**	***	*		†	*	*			†							†		
	1	B	P	6.1	14.7	0.1	0.0	1.8	0.2	0.4	1.3	0.0	9.4	0.5	1.9	8.5	5.3	0.0	0.6	9.2	0.2	60.8
			sig.level	+		*																
	2	B	P	11.7	16.3	0.5	0.0	0.1	0.4	1.3	-	0.0	6.2	2.1	1.5	9.1	5.8	3.2	0.6	7.3	0.0	53.8
			sig.level	**	***									***								
MM20	5	B	P	52.5	34.6	1.9	0.0	0.1	0.1	-	-	0.0	5.0	16.5	1.3	9.3	14.2	0.1	0.1	5.5	0.1	79.2
			sig.level		***	+	†						+		**		**		†			
TO2	9	B	P	40.1	17.2	4.8	0.0	0.0	0.0	0.1	-	0.1	13.3	17.5	9.2	7.9	0.0	0.0	0.3	1.8	0.0	92.6
MM14	0	B	O	0.7	0.6	0.1	0.1	0.1	0.2	0.2	-	0.0	4.1	0.4	4.6	3.6	2.6	0.0	0.2	0.4	0.3	30.0
			sig.level	***	***	***			+					***							***	
	1	B	O	31.1	11.8	0.2	0.0	0.1	0.0	1.0	2.3	0.1	0.8	2.7	2.7	5.7	3.3	0.1	0.4	0.8	0.1	34.3
			sig.level			**	+						*									
	2	B	O	47.1	11.4	3.4	0.0	0.0	0.1	0.8	2.0	0.0	11.7	2.2	1.6	6.6	4.6	0.0	0.3	0.9	0.1	41.9
			sig.level	***	**		**	+						*	***							
MM20	5	B	O	109.6	34.9	4.4	0.3	0.4	0.2	0.3	-	0.0	15.4	12.0	14.3	6.1	2.2	1.8	0.7	0.7	0.1	67.6
			sig.level			*							+	***	-		*					**
TO2	9	B	O	66.4	17.6	28.9	0.0	0.0	0.8	0.8	-	0.1	34.9	45.6	4.7	0.3	5.0	0.1	0.7	1.4	0.1	80.5

TABLE 13 cont'd

(D) Comparison of fuel components between ages of regeneration and between treatments for vegetation type P.

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GMF	GDT
MM14	(0) adv	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
			sig. level																			
	(1) adv	UB	P	22.8	16.6	0.2	0.0	0.9	0.2	1.0	2.0	0.0	16.7	4.8	32.9	33.7	15.9	10.2	0.9	11.9	15.6	204.9
			sig. level			*									†							
	(2) adv	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
MM14	(0) adv	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
			sig. level		*	**								†	*	†						
	(2) adv	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
MM14	(0) adv	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
			sig. level	***	***	†			*	†				**	***	***				**	***	***
MM20	5	B	P	52.5	34.6	1.9	0.0	0.1	0.1	-	-	0.0	5.0	16.5	1.3	9.3	14.2	0.1	0.1	5.5	0.1	79.2
MM14	(0) adv	UB	P	17.0	7.4	0.0	0.0	1.3	0.3	1.3	1.8	0.0	7.0	2.5	23.7	35.0	14.9	7.9	0.0	20.4	18.3	157.5
			sig. level			***		†						**	†	***	***			***	***	***
TO2	9	B	P	40.1	17.2	4.8	0.0	0.0	0.0	0.1	-	0.1	13.3	17.5	9.2	7.9	0.0	0.0	0.3	1.8	0.0	92.6
MM14	(2) adv	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
			sig. level	**					*	†		*			**	***		*			***	**
MM20	5	B	P	52.5	34.6	1.9	0.0	0.1	0.1	-	-	0.0	5.0	16.5	1.3	9.3	14.2	0.1	0.1	5.5	0.1	79.2
MM14	(2) adv	UB	P	20.7	27.5	2.2	0.0	0.3	0.2	1.1	2.0	0.0	9.6	8.1	6.9	19.4	18.1	12.5	0.3	9.7	15.0	155.1
			sig. level									†				***	***	**		**	***	***
TO2	9	B	P	40.1	17.2	4.8	0.0	0.0	0.0	0.1	-	0.1	13.3	17.5	9.2	7.9	0.0	0.0	0.3	1.8	0.0	92.6

(E) Comparison of fuel components between ages of regeneration and between treatments for vegetation type O.

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GMF	GDT
MM14	(0) adv	UB	O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
			sig. level																			
	(1) adv	UB	O	24.1	15.5	1.7	0.1	5.3	0.5	0.0	1.2	0.0	36.4	15.5	14.4	41.4	18.0	20.1	0.3	14.7	19.7	220.1
			sig. level																			
	(2) adv	UB	O	43.4	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6
MM14	(0) adv	UB	O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
			sig. level		+										+							
	(2) adv	UB	O	43.4	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6
MM14	(0) adv	UB	O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
			sig. level	***	**							**	+			***	***	**		***	***	***
MM20	5	B	O	109.6	34.9	4.4	0.3	0.4	0.2	0.3	-	0.0	15.4	12.0	14.3	6.1	2.2	1.8	0.7	0.7	0.1	67.6
MM14	(0) adv	UB	O	18.9	11.0	0.4	0.2	6.7	0.4	0.6	2.4	0.1	39.2	11.7	34.8	60.1	18.5	14.4	11.4	17.7	25.5	286.1
			sig. level	**		***	*	**	**	†				*		***	***	***		***	***	***
TO2	9	B	O	66.4	17.6	28.9	0.0	0.0	0.8	0.8	-	0.1	34.9	45.6	4.7	0.3	5.0	0.1	0.7	1.4	0.1	80.5
MM14	(2) adv	UB	O	43.4	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6
			sig. level	**					**	*	*	+				***	***	***		***	***	***
MM20	5	B	O	109.6	34.9	4.4	0.3	0.4	0.2	0.3	-	0.0	15.4	12.0	14.3	6.1	2.2	1.8	0.7	0.7	0.1	67.6
MM14	(2) adv	UB	O	43.4	23.1	4.5	0.0	2.2	0.1	0.0	1.9	0.0	24.6	11.1	11.8	45.1	35.6	23.3	0.2	13.6	11.9	264.6
			sig. level			**	*		**	**	*			+		***	***	***		***	***	***
TO2	9	B	O	66.4	17.6	28.9	0.0	0.0	0.8	0.8	-	0.1	34.9	45.6	4.7	0.3	5.0	0.1	0.7	1.4	0.1	80.5

TABLE 13 cont'd

(F) Comparison of fuel components between ages of regeneration and treatments for the high altitude coupes dominated by *Eucalyptus delegatensis* and *E. obliqua* (D/O).

Coupe	Age of re-generation (years)	Treatment	Vegetation type	A/GL	GL	ADV	ALE	AT1	AT2	AT3	AT4	AB	AGDT	GDV	GLE	GT1	GT2	GT3	GT4	GB	GHF	GDT
TO30	8	B	D/O	73.9	9.5	21.6	0.0	0.1	0.2	0.1	-	0.0	28.0	21.6	6.2	6.0	2.1	0.2	0.2	1.0	6.7	85.4
			sig.level					**		†	†	***		**	†	***	***	***	**	**	***	***
	(8) adv	UB	D/O	73.3	11.4	3.4	0.0	11.5	0.0	0.1	0.8	0.5	55.9	5.4	17.6	41.7	17.3	23.3	0.6	11.2	42.7	247.6
TO56	7	B	D/O	47.2	12.5	48.5	0.0	0.0	0.3	0.5	-	0.0	55.2	65.9	3.8	7.7	3.6	0.0	0.5	2.0	2.7	109.4
			sig.level												**	**	†	**			***	**
	(7) adv	UB	D/O	43.4	8.5	24.7	0.0	0.2	0.1	0.5	0.9	0.2	38.5	66.3	18.1	16.8	12.4	19.2	0.1	4.7	15.5	197.0
TO30	8	B	D/O	73.9	9.5	21.6	0.0	0.1	0.2	0.1	-	0.0	28.0	21.6	6.2	6.0	2.1	0.2	0.2	1.0	6.7	85.4
			sig.level									†		†			*					
TO56	7	B	D/O	47.2	12.5	48.5	0.0	0.0	0.3	0.5	-	0.0	55.2	65.9	3.8	7.7	3.6	0.0	0.5	2.0	2.7	109.4
TO30	(8) adv	UB	D/O	73.3	11.4	3.4	0.0	11.5	0.0	0.1	0.8	0.5	55.9	5.4	17.6	41.7	17.3	23.3	0.6	11.2	42.7	247.6
			sig.level			†		**	*			***		***		†					**	
TO56	(7) adv	UB	D/O	43.4	8.5	24.7	0.0	0.2	0.1	0.5	0.9	0.2	38.5	66.3	18.1	16.8	12.4	19.2	0.1	4.7	15.5	197.0
TO30	8	B	D/O	73.9	9.5	21.6	0.0	0.1	0.2	0.1	-	0.0	28.0	21.6	6.2	6.0	2.1	0.2	0.2	1.0	6.7	85.4
			sig.level											†		**	***	***	**		*	***
TO56	(7) adv	UB	D/O	43.4	8.5	24.7	0.0	0.2	0.1	0.5	0.9	0.2	38.5	66.3	18.1	16.8	12.4	19.2	0.1	4.7	15.5	197.0
TO30	(8) adv	UB	D/O	73.3	11.4	3.4	0.0	11.5	0.0	0.1	0.8	0.5	55.9	5.4	17.6	41.7	17.3	23.3	0.6	11.2	42.7	247.6
			sig.level			**		***	†		†	*		***	***	***	**	***		**	***	***
TO56	7	B	D/O	47.2	12.5	48.5	0.0	0.0	0.3	0.5	-	0.0	55.2	65.9	3.8	7.7	3.6	0.0	0.5	2.0	2.7	109.4

at MM14 ($p = 0.001$). However, levels recorded at MM20 did not differ from those at T02 at $p = 0.05$.

Total above-ground dead material (AGDT) was significantly greater at $p = 0.02$ between ages one and two only. Above-ground dead herbaceous vegetation (ADV) increased from age zero to age two ($p = 0.01$) but showed no significant difference between age two and age five. However, ADV in the 5 year-old regeneration was significantly less than in the 9 year-old regrowth ($p = 0.02$).

Total dead ground fuel (GDT) only differed between samples from MM20 and T02, the latter site having greater levels at $p = 0.01$. Of the separate dead ground components, herbaceous vegetation (GDV) showed the most consistent increase in successive samplings.

4.4.1.4 Comparison of fuel components between ages of regeneration and between treatments

(1) Type P (Table 13D)

The weight of individual fuel components did not differ at $p = 0.05$ between regeneration of age zero and age one on treatment UB at MM14. Elevated dead vegetation (ADV) was the only component that differed at $p = 0.02$ between age one and age two.

Comparing the unburnt regrowth of ages zero and two, live ground material (GL) and elevated dead herbaceous vegetation (ADV) were greater at age two at $p = 0.02$, whilst dead leaves on the ground (GLE) were less.

Above-ground live material (A/GL) was greater in the 5 year-old regrowth at MM20 than in the regeneration on treatment UB, MM14, at ages zero and two ($p = 0.01$). However, levels of A/GL at T02 did not differ from those at MM14 at $p = 0.05$.

Total above-ground dead fuel (AGDT) showed no significant difference at $p = 0.05$ between treatment UB, MM14, and levels recorded at MM20 and T02, at ages zero and two. T02 had higher levels of elevated dead herbaceous vegetation (ADV) than age 0, treatment UB, MM14 ($p = 0.001$), but did not differ at $p = 0.05$ from age two at MM14.

Total dead ground fuel (GDT) was significantly greater on treatment UB, MM14 at ages zero and two compared to both MM20 and T02 ($p = 0.01$). The separate fuel components were generally greater in the unburnt treatments at $p = 0.02$, or showed no significant difference with the results from MM20 and T02. T02 had greater levels of dead herbaceous vegetation than did MM14, age zero ($p = 0.01$), but did not differ at $p = 0.05$ from levels at MM14, age two.

(2) Type O (Table 13E)

Weights of fuel components did not differ between ages of regeneration at MM14 at $p = 0.02$. Above-ground live material (A/GL) at age zero, MM14, was less ($p = 0.02$) than levels at either MM20 or T02. However, by age two there was no significant difference at $p = 0.05$ with levels of elevated live material at T02. Live ground material (GL) appeared similar between the various sampling periods at MM14, MM20 and T02.

Total above-ground dead fuel (AGDT) did not differ at $p = 0.02$ between MM14, MM20 and T02. However, the above-ground components, herbaceous vegetation (ADV), twigs 0.5-1.0cm in diameter and twigs 1.0-1.5cm in diameter (AT2 and AT3) were greater at $p = 0.02$ in the 5 year-old and 9 year-old regeneration than in the ages of regrowth sampled at MM14.

The total levels of ground material (GDT) were consistently greater (p = 0.001) on treatment UB, MM14, than on those at MM20 and TO2. The separate fuel components were generally greater on treatment UB (p = 0.02) or showed no significant difference, with levels recorded at MM20 and TO2. Dead ground vegetation was greater at TO2 than at MM14, age zero (p = 0.02) but only differed weakly (p = 0.05) from age two.

4.4.2 Fine fuel within vegetation type D/O (Table 13F)

4.4.2.1 Comparison between burnt and unburnt treatments for the same age of regeneration

Totals of above-ground live and dead material (A/GL and AGDT) showed no significant difference (p = 0.05) between burnt and unburnt treatments in either 7 or 8 year-old regeneration. Of the elevated dead components, only bark (AB) and twigs <0.5cm in diameter (AT1) differed at p = 0.02 between treatments in the 8 year-old regrowth. In this instance, levels were greater on the unburnt treatment compared to the burnt treatment for both AB and AT1.

Ground fuel components were generally significantly less on the burnt treatment than on the unburnt treatment at p = 0.02. Fallen leaves (GLE) differed weakly (p = 0.05) between the treatments in the 8 year-old regrowth, whilst dead herbaceous vegetation (GDV) was greater on the burnt treatment than on the unburnt site (p = 0.01). Leaves (GLE), twigs <0.5cm and 1.0-1.5cm in diameter (GT1 and GT3), and miscellaneous fine material (GMF) were all less (p = 0.01) on the burnt treatment than on the unburnt treatment in the 7 year-old regrowth at TO56.

At both TO30 and TO56 the total dead ground material (GDT) was greater on the unburnt treatment than on the burnt (p = 0.01).

4.4.2.2 Comparison of the burnt treatment between ages of regeneration

Individual fuel components did not differ between the 7 and 8 year-old regeneration at $p = 0.02$.

4.4.2.3 Comparison of the unburnt treatment between ages of regeneration

The live fuel categories did not differ significantly between ages seven and eight. Elevated twigs <0.5cm in diameter, and elevated bark (AB) were greater at age eight than at age seven ($p = 0.01$), whilst twigs 0.5-1.0cm in diameter were greater in the latter age ($p = 0.02$). Total above-ground dead material (AGDT) did not differ at $p = 0.05$ between the two ages.

Ground fuel totals were similar in the 7 year-old and the 8 year-old regrowth. Only dead herbaceous vegetation (GDV) and miscellaneous fine material (GMF) of the individual components differed at $p = 0.02$. T056 had higher levels in the former and lower in the latter.

4.4.2.4 Comparison of the burnt and unburnt treatments between ages of regeneration

Live material (A/GL and GL) and all elevated dead components did not differ at $p = 0.05$ between the 8 year-old regeneration on the burnt treatment at T030 and the 7 year-old advanced regeneration at T056.

Total dead ground material (GDT) was less on the burnt treatment at age eight than on the unburnt at age seven ($p = 0.001$). All twig categories differed at $p = 0.02$ between the two treatments and regrowth ages. All were less on the burnt treatment than on the unburnt treatment except for GT4 which was greater on the latter.

Live material did not differ at $p = 0.05$ between the age seven regrowth on the burnt treatment and the advanced 8 year-old regeneration. Total above-ground dead fuel (AGDT) was also similar between the two ages and treatments. However, above-ground herbaceous vegetation (ADV) was greater ($p = 0.01$) at T056 on the burnt treatment than at T030 on the unburnt treatment, whilst elevated twigs <0.5cm in diameter and bark (AB) were less ($p = 0.02$).

With the exception of dead ground herbaceous vegetation (GDV) and twigs 1.5-2.0cm in diameter (GT4), all dead ground fuel components were significantly less on the age seven burnt treatment than on the age eight unburnt treatment ($p = 0.02$). GT4 did not differ at $p = 0.05$ whilst GDV was greater on the burnt treatment than on the unburnt ($p = 0.001$).

4.4.3 Coarse fuel within vegetation types P and O

There was no significant difference at $p = 0.02$ in the total volume of material (TOTAL: Table 14) between MM14, MM20 and T02, regardless of the treatment or vegetation type.

The volume of fuel, both above-ground (A/GD) and at ground level (GD), did not differ between ages of regeneration, treatment or vegetation type at $p = 0.02$. Elevated material differed weakly at $p = 0.05$ only.

Median values for each category of material are shown in Table 14.

4.4.4 Coarse fuel within vegetation type D/O

There was no significant difference in the volume of elevated material at ground level or the total volume of material between ages of regeneration or treatment ($p = 0.02$). Median values are given in Table 14.

TABLE 14 :

Median values for volume (cm^3) of coarse fuel in various ages of regeneration, treatment and vegetation type.

GD: material resting on the ground
A/GD: elevated material
TOTAL: combined total of elevated and ground material

Coupe	Age of re-generation (years)	Treatment	Vegetation type	Volume (cm^3) GD	A/GD	TOTAL
MM14	0	B	P	2	13	35
			O	49	3	403
	(0) adv	UB	P	3	14	117
			O	240	0	1227
	1	B	P	12	9	120
			O	87	97	117
	(1) adv	UB	P	16	2	116
			O	109	23	601
	2	B	P	219	34	574
			O	249	70	396
	(2) adv	UB	P	54	18	94
			O	140	2	933
MM20	5	B	P	76	22	127
			O	312	417	1016
TO2	9	B	P	96	11	752
			O	2	3	14
TO56	7	B	D/O	4	14	13
	(7) adv	UB	D/O	226	6	1239
TO30	8	B	D/O	254	3	254
	(8) adv	UB	D/O	316	5	316

4.4.5 Total fuel left as a result of clearfelling at MM14

The total weight of fine fuel left as a result of clearfelling on treatment UB was 13.3 tonnes/ha. The total volume of coarse fuel left on treatment UB was 127 m^3/ha (equivalent to 134 tonnes/ha).

4.4.6 Height/depth of fine fuel

4.4.6.1 Elevated above-ground material (A/GD and A/GL) within vegetation types P and O (Table 15A)

The maximum height of live and dead above-ground material (A/GL and A/GD) occurred with the greatest frequency in the 0-20cm class on treatment B, MM14, at regrowth age zero. Percentage frequency in the height classes above 0-20cm became greater with increasing age of regeneration.

On treatment UB, MM14, above-ground dead material (A/GD) was most frequent in the 0-20cm height class in the youngest age of regeneration. Height of material showed a wider distribution over the various height classes in the 1 year-old and 2 year-old advanced regeneration than at age zero. Height of above-ground live material (A/GL) was distributed through several classes in all regeneration ages on treatment UB.

4.4.6.2 Live and dead ground fuel (GL and GD) within vegetation types P and O (Table 15A)

Material >0.5cm in depth was most frequent on treatment UB, MM14. On the burnt treatments fuel depths were most frequent from 0-15cm. Depths of material in regeneration aged zero and one on treatment B were most common in the 0-5cm class.

TABLE 15

Maximum height/depth (cm) of four general fine fuel categories recorded in various ages of regeneration, treatment and vegetation type. Figures represent the percentage of the number of quadrats sampled in the particular age of regeneration, treatment and vegetation type, occurring in each height/depth category.

(A) vegetation types P and O. (B) vegetation type D/O.

A/GD = elevated dead material: GD = dead ground material

A/GL = elevated live material: GL = live ground material

(A)

Coupe		MM14			MM20	TO2	MM14			MM20	TO2	MM14			MM14		
Age of regeneration (years)		0	1	2	5	9	0	1	2	5	9	(0)	(1) adv.	(2)	(0)	(1) adv.	(2)
Treatment: vegetation type		B:P					B:O					UB:P			UB:O		
	Height (cm)	% frequency					% frequency					% frequency			% frequency		
FUEL CATEGORY = A/GD	0 - 20	67	28	24	16	8	72	44	22	4	0	46	19	4	50	44	8
	20 - 40	8	24	20	52	24	4	15	15	52	4	21	23	27	10	15	20
	40 - 60	8	20	24	20	16	8	19	33	24	4	4	23	38	15	19	32
	60 - 80	4	8	20	12	28	-	11	11	12	36	8	4	27	15	11	16
	80 - 100	8	12	-	-	16	8	-	4	8	16	13	15	-	-	-	-
	100 - 120	4	-	4	-	4	-	-	4	-	28	4	4	-	-	-	8
	120 - 140	-	4	-	-	-	-	4	4	-	8	4	8	-	10	4	4
	140 - 160	-	4	8	-	-	-	4	-	-	0	-	4	4	-	4	8
	160 - 180	-	-	-	-	-	8	-	4	-	4	-	-	-	-	-	4
	180 - 200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	200 - 220	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
	220 - 240	-	-	-	-	-	4	4	-	-	-	-	-	-	-	4	-
	240 - 260	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
FUEL CATEGORY = A/GL	0 - 20	58	28	12	-	8	60	11	11	-	-	13	8	4	10	-	8
	20 - 40	25	36	40	4	16	20	22	7	4	4	4	23	23	20	20	12
	40 - 60	13	16	24	28	12	20	33	15	4	16	25	12	23	25	24	20
	60 - 80	-	8	12	40	24	-	15	26	36	16	13	19	8	15	12	8
	80 - 100	4	8	-	8	12	-	11	15	16	12	25	8	23	10	12	12
	100 - 120	-	-	-	16	4	-	4	11	28	8	13	8	8	5	4	4
	120 - 140	-	-	12	4	8	-	4	7	8	12	8	4	4	10	16	12
	140 - 160	-	-	-	-	12	-	-	7	-	-	-	4	-	-	4	12
	160 - 180	-	4	-	-	-	-	-	-	4	4	-	4	4	5	4	4
	180 - 200	-	-	-	-	-	-	-	-	-	4	-	4	-	-	-	4
	200 - 220	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	4
	220 - 240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
	240 - 260	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
	260 - 280	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
	280 - 300	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
	300 - 320	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
	320 - 340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	340 - 360	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-

TABLE 15(A) cont'd

Coupe		MM14			MM20	TO2	MM14			MM20	TO2	MM14			MM14		
Age of regeneration (years)		0	1	2	5	9	0	1	2	5	9	(0)	(1) adv.	(2)	(0)	(1) adv.	(2)
Treatment: vegetation type		B:P					B:O					UB:P			UB:O		
	Depth (cm)	% frequency					% frequency					% frequency			% frequency		
FUEL CATEGORY = GD	0 - 5	79	80	68	8	64	100	70	52	16	24	46	46	54	35	48	32
	5 - 10	21	16	28	40	24	-	26	44	68	56	33	27	23	35	24	28
	10 - 15	-	-	4	52	12	-	4	4	16	20	17	23	19	15	16	16
	15 - 20	-	-	4	-	-	-	-	-	-	-	-	-	4	10	8	20
	20 - 25	-	-	-	-	-	-	-	-	-	-	4	4	-	-	4	-
	25 - 30	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	-
	30 - 35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
FUEL CATEGORY = GL	0 - 5	79	76	40	8	44	96	70	44	16	24	38	35	35	30	48	36
	5 - 10	8	20	52	40	28	-	19	37	68	56	33	38	35	25	24	20
	10 - 15	8	4	8	52	28	4	11	15	16	20	21	23	27	30	20	20
	15 - 20	4	-	-	-	-	-	-	4	-	-	-	4	4	15	4	20
	20 - 25	-	-	-	-	-	-	-	-	-	-	4	-	-	-	4	-
	25 - 30	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
	30 - 35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4

TABLE 15(B)

	FUEL CATEGORY = A/GD				FUEL CATEGORY = A/GL			
Coupe	TO56	TO30	TO56	TO30	TO56	TO30	TO56	TO30
Age of regeneration (years)	7	8	(7) adv	(8) adv	7	8	(7) adv	(8) adv
Treatment: vegetation type	B: D/O		UB: D/O		B: D/O		UB: D/O	
Height (cm)	% frequency				% frequency			
0 - 20	8	4	4	8	4	-	-	-
20 - 40	28	32	36	32	-	12	4	-
40 - 60	48	40	28	20	16	16	40	12
60 - 80	16	16	16	8	48	12	16	20
80 - 100	-	4	4	8	4	16	-	-
100 - 120	-	-	4	4	12	4	-	28
120 - 140	-	-	8	4	-	12	4	8
140 - 160	-	-	-	8	12	8	4	4
160 - 180	-	-	-	-	-	4	8	16
180 - 200	-	-	-	-	4	8	-	-
200 - 220	-	-	-	4	-	-	-	4
220 - 240	-	4	-	-	-	-	4	-
240 - 260	-	-	-	-	-	-	-	-
260 - 280	-	-	-	-	-	-	-	-
280 - 300	-	-	-	-	-	-	-	-
300 - 320	-	-	-	-	-	-	-	4
320 - 340	-	-	-	4	-	-	-	-
340 - 360	-	-	-	-	-	4	-	-
360 - 380	-	-	-	-	-	-	-	-
380 - 400	-	-	-	-	-	-	-	4
400 - 420	-	-	-	-	-	4	-	-
980 - 10000	-	-	-	-	-	-	4	-

TABLE 15(B) cont'd

	FUEL CATEGORY = GD				FUEL CATEGORY = GL			
Coupe	TO56	TO30	TO56	TO30	TO56	TO30	TO56	TO30
Age of regeneration (years)	7	8	(7) adv	(8) adv	7	8	(7) adv	(8) adv
Treatment: vegetation type	B: D/O		UB: D/O		B: D/O		UB: D/O	
Depth (cm)	% frequency				% frequency			
0 - 5	24	60	32	40	44	80	52	56
5 - 10	68	36	52	36	48	20	36	28
10 - 15	8	4	16	24	8	-	12	16

4.4.6.3 Elevated above-ground material within vegetation type D/O (Table 15B)

Regeneration on burnt and unburnt sites had similar height distribution with frequencies highest in the classes from 20-80cm. Live material showed a wider distribution in height than did dead, but was similar between burnt and unburnt treatments.

4.4.6.4 Live and dead ground fuel (GL and GD) within vegetation type D/O (Table 15B)

The greatest frequencies of ground fuel depth occurred in the classes from 0-10cm in both 7 and 8 year-old regeneration on burnt and unburnt treatments.

4.5 DISCUSSION

The importance of fuel size in fire behaviour, and the consequent preferential removal of fine fuel, is well known (e.g. Childs, 1939; McArthur, 1962; Brown, 1970b; Countryman and Philpot, 1970; Brown, 1972; Cheney, 1981). Similarly, the general observation that slash-burning does not significantly reduce the levels of coarse fuels on clearfelled treatments has also been noted (Bowman and Jackson, 1981).

Fine fuels are considered of great importance with respect to the rate of fire spread (e.g. Brown, 1972; Cheney, 1981; Raison et al., 1983). The high surface-area-to-volume ratios of fine fuels make them highly susceptible to changes in moisture content (Brown and Davis, 1973; Fujioka, 1976) and make them respond rapidly to radiative heating in advance of a flame front (Brown, 1970a; Frandsen, 1973). In contrast, coarse fuels only attain ignition temperatures near the surface because of low heat conduction (Frandsen, 1973). In North American studies, opinions vary as to the energy contribution and the role of coarse slash fuels in fire behaviour. For instance, Fahnestock (1960) stated that coarse fuels contributed significantly to fire spread, intensity and duration when the moisture content of the peripheral 2.5cm approached 10%. However, Brown (1970b) maintained that material >10cm in diameter (comprising 80% of the total slash volume) contributed relatively little energy to fire spread, and hence had little effect on the intensity of a fire front.

Previous investigations involving fuels and fire in Australia have differed in their choice of upper size limit of fine fuel, the criteria for which are unclear and apparently subjective (Cheney, 1981). For example, McArthur (1962) chose 0.6cm, Peet (1965) chose 1.25cm, Van Loon (1977) chose 2.5cm, whilst Sneeuwjagt and Peet (1979) selected 1cm. The present study showed that, in most cases, the most dynamic fuel components were those less than 1.5cm in diameter or thickness. The weights of twigs 1.5-2.0cm in diameter (GT4) were, in general, not significantly different between burnt and unburnt treatments, or between ages of regeneration.

Data from the present study imply that the accumulation of fine ground fuel following slash-burning does not attain levels equivalent to those on unburnt treatments for at least 9 years after fire in types P and O, and after 8 years in type D/O. However, ground fuel levels in unburnt treatments appear to have equal rates of decomposition and accumulation, there being no significant difference in fuel loads between successive ages of regeneration.

In types P and O, elevated dead material on burnt treatments equilibrates to levels similar to those on unburnt treatments within two years of burning. Similarly, live vegetation, both elevated and at ground level, recovers rapidly following fire, and may in certain instances exceed levels on equivalent unburnt sites.

Of the dead fine fuel components, decorticating gum bark and dead herbaceous vegetation appeared favoured by burning. Levels of the latter were greater 5 years after slash-burning than on clearfelled sites 2 years after logging with slash left unburnt. The increase of dead herbaceous vegetation in the first few years following slash-burning was also noted by Childs (1939). Dead fuel often forms a continuum with live fuel causing the latter to become involved in the combustion process (McNab et al., 1978; Mount, 1979). Green vegetation has been viewed as a firebreak in temperate North America (Brown and Davis, 1973). However, in mediterranean ecosystems, such as in California and southern Australia, the presence of understorey plants may affect fire spread by flame contact and also by influencing wind fields (Countryman and Philpot, 1970; Cheney, 1981). In addition, the live biomass may provide highly volatile foliage (Countryman and Philpot, 1970; Raison et al., 1983; see also Chapter 5).

Fine fuel levels recorded at MM14 are slightly less than the equilibrium weights of approximately 15 to 17 tonnes/ha found in productive forest sites in New South Wales 3 to 4 years after prescribed burning (Van Loon, 1969). Van Loon (1977) found a mean annual increase of 1.7 tonnes/ha in ground fuel weights in the first 6 to 7 years after controlled burning in dry forests, and speculated that litter decomposition does not become efficient until a litter layer of about 13 tonnes/ha is established. Raison et al. (1983) quote fine fuel weights of 12 tonnes/ha as dangerous, accumulating in most eucalypt forest types in 6 or less years following prescribed burning.

The quantity of coarse fuel left as a result of clearfelling in types P and O is similar to other quoted figures for dry forests. Figures cited by Bowman and Jackson (1981) indicate that 150 tonnes/ha of coarse fuel were left after clearfelling and slash-burning in the forests at Eden, New South Wales.

The significance of fine fuel on a particular site, with regard to fire hazard, is a function of its continuity (Brown and Davis, 1973; Artley et al., 1978; Frandsen and Andrews, 1979), the degree of elevation (Fahnestock and Dieterich, 1962; Brown, 1970b) the degree of compaction (Fahnestock, 1960; Brown, 1970b; Countryman and Philpot, 1970), and the weight and volume of the fuel components. Fine slash fuels gravitate towards the ground with time (Fahnestock, 1960; Brown, 1970b) with resulting increased compaction of fuels and decreasing fire hazard, although there can be some interspecific variation (Fahnestock and Dieterich, 1962).

There was some evidence at MM14 that dead elevated leaves and small dead elevated twigs tend to move towards the ground on unburnt sites. The vertical structure of live and dead fuels on burnt sites became more evenly distributed with increasing age of regeneration. In the case of live material, the above-ground vertical fuel structure on burnt treatments rapidly approached the structure present on unburnt treatments.

The present study appears to support the opinions expressed by both Mount (1979) and Bowman and Jackson (1981). Slash-burning does significantly reduce the total fine fuel load but it is ineffective in reducing the volume of coarse fuels. The reduction of fine fuel is only persistent through time in the compacted ground fuel layer, as the regenerating stand rapidly recovers the above-ground vertical fine fuel structure. On burnt treatments live material and dead herbaceous vegetation often comprise the greater proportion of the aerated, above-ground fuel assemblage than that which is present on unburnt treatments.

CHAPTER 5

THE FLAMMABILITY AND ENERGY CONTENT OF SOME IMPORTANT PLANT SPECIES AND FUEL COMPONENTS IN THE DRY AND WET FORESTS OF SOUTHEASTERN TASMANIA

5.1 INTRODUCTION

Mutch (1970) hypothesized that fire-dependent plant communities burn more readily than non fire-dependent communities because natural selection has favoured development of characteristics that make fire-dependent species more flammable. This hypothesis was also made explicit by Mount (1964) and Jackson (1968), both of whom wrote on the role of fire in the patterning of Tasmanian vegetation. There exists a considerable volume of literature on the definition of flammability and the relationship of flammability with the chemical and morphological attributes of plant species (e.g. Broido and Nelson, 1964; Pompe and Vines, 1966; King and Vines, 1969; Anderson, 1970; Philpot, 1970, 1977; Mutch and Philpot, 1970; Montgomery and Cheo, 1971; Trabaud, 1976; Shafizadeh et al., 1977; Gill, 1978; Gill et al., 1978). However, unequivocal data confirming the Mutch hypothesis were considered to be lacking by Rundel (1981) and there has been little of either the experiment or measurement considered necessary for its verification by Gill (1975).

In Tasmania, native plant communities consisting of fire requiring species exist in close proximity to plant communities composed of species poorly adapted to fire (Jackson, 1968; Brown and Podger, 1982). In southeastern Tasmania, dry forests dominated by Eucalyptus (including types P and O) and Casuarina are interspersed with wet forest communities (Fig. 21) which contain small patches of rainforest dominated by Atherosperma moschatum, and gully scrub dominated variously by the broad-leaved composites, Pomaderris apetala and Beyeria viscosa. These latter communities occupy the most mesic and least-burned localities within the wet forest.

The mosaic of forest types found in southeastern Tasmania presents an excellent opportunity to test the Mount, Jackson and Mutch hypothesis. The hypothesis, if true, has long-term implications for fire hazard in forests where burning is used as part of management, and

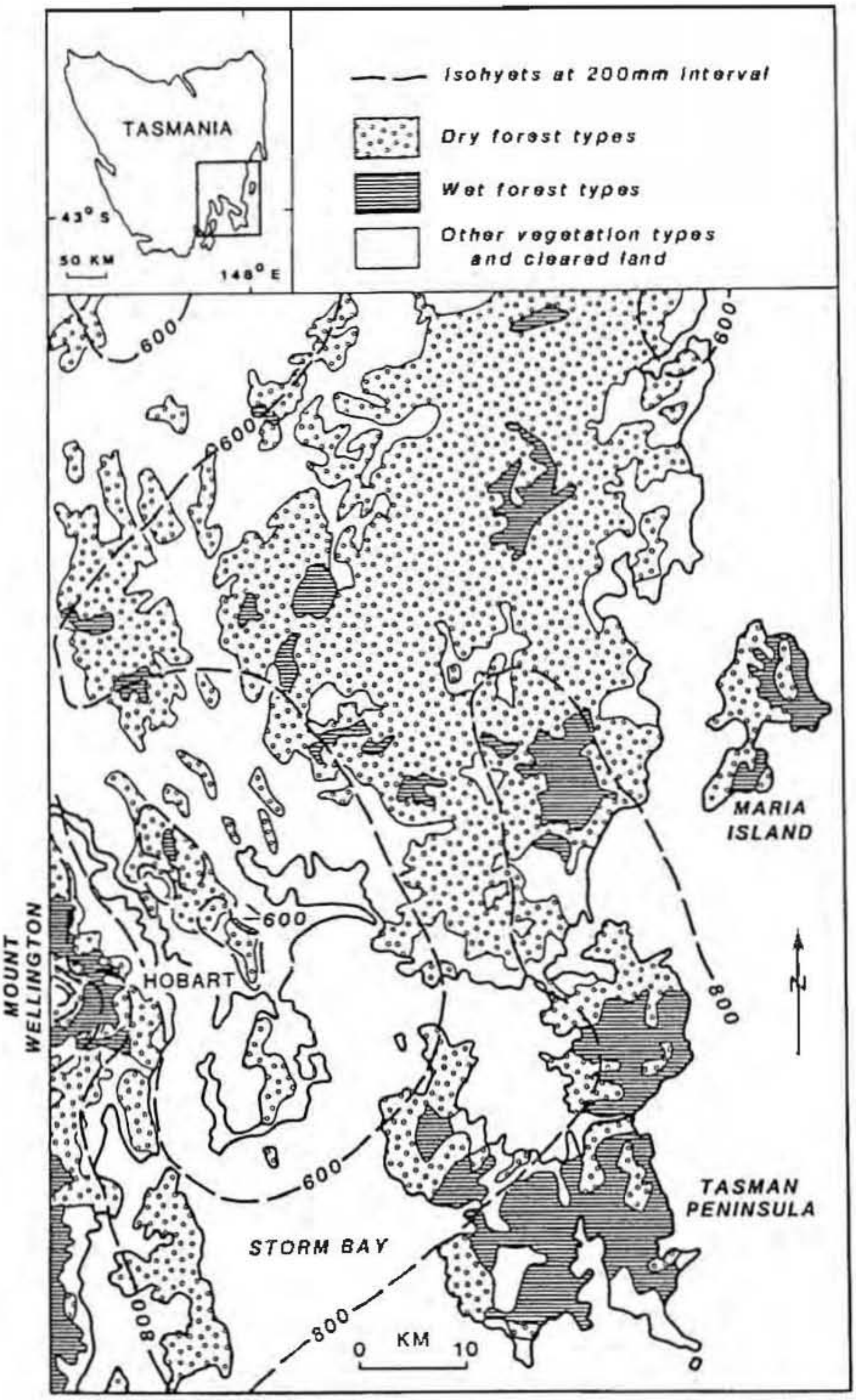


Fig. 21 : Distribution of dry and wet forest, generalised from Kirkpatrick and Dickinson (1984), and precipitation (Bureau of Meteorology, personal communication, and 1978) in southeastern Tasmania. Gully scrub and rainforest occur in small pockets in the most mesic part of the wet forest.

consequently has particular relevance to the communities studied in Chapters 2 to 4.

This chapter explores the relationship between the fire ecology and flammability of plant species common in the dry forests (see Chapter 2) and the wet forests which occur on dolerite in southeastern Tasmania. Measurements of calorific content, ash content and silica content, together with the speed of flame propagation, are made for fine fuels <1.5cm in diameter or thickness, for the live and dead categories described in Chapter 4.

5.2 METHODS

Foliage, twigs and litter typical of the species occurring in dry and wet forests on dolerite were all collected in the environs of Hobart during winter 1983. As winter is a time of little or no growth for all the species, relative calorific values should have greater reliability than in the warmer times of the year when species can differ greatly in their phenology (Singh and Yadava, 1973; Caspers, 1977).

For calorimetric analysis, all material was oven-dried for 48 hours at 105^{o}C and ground to 60 mesh in a Wiley mill. Individual samples were thoroughly mixed, subsamples extracted and placed in a sealed cabinet over water trays to bring them to sufficient moistness to allow compaction into 0.5-1.0g pellets. The pellets were analysed using a Gallenkamp automatic adiabatic bomb calorimeter at 30 atmospheres of oxgygen. The analyses were replicated, a third or fourth analysis being undertaken where the replicate values differed by more than 2.5%. Percentage moisture contents of all analysed subsamples were obtained from duplicates. These percentage values were employed to correct samples to dry weight which was used in the determination of calorific content. Energy values were calculated using the formula:

$$H = \frac{(W.E. + W)\ c\ dT}{m}$$

where H = the heat of combustion (Jg^{-1})

$W.E.$ = the water equivalent of the calorimeter (g)

W = the weight of water used in the calorimeter (g)

c = the specific heat of water at temperature, T ($Jg^{-1}\ {}^{o}K^{-1}$)

dT = the temperature increase (${}^{o}K$) induced by the pellet combustion

m = the mass of the pellet used (g)

The water equivalent of a particular calorimeter is calculated from the formula:

$$W.E. = \frac{m\ Q}{c\ dT} - W$$

and is obtained by the combustion of a substance with a known energy content (Q). Benzoic acid is the most widely used chemical standard, having a heat of combustion of 26,442 Jg^{-1}. Benzoic acid pellets were fired in the calorimeter until three successive calculations of the water equivalent showed little change. The average of these results was then used in subsequent calculations of the unknown energy contents. Calibration using benzoic acid pellets was repeated at intervals during the main volume of the calorimetry tests, and any necessary adjustments to the water equivalent were taken into account.

Thermochemical corrections were made to the calorific calculations to allow for the heat of combustion of the tungsten fuse wire, which was 7.46 $Jg^{-1}cm^{-1}$ (B.V. O'Grady, personal communication, 1983).

Ash contents were determined for duplicate subsamples of all the fuel materials tested in the calorimeter, by calculating the percentage of the initial weight remaining after 4 hours at 550°C in a muffle furnace. In addition, various species and components showing a range of ash contents were analysed for percentage silica content by hydrofluoric acid digestion.

Flammability experiments and observations were made with both live and dead material, the former being collected in polythene bags immediately before any testing took place. Dead material was oven-dried at 80°C for 24 hours before testing. The temperature 80°C was used in order to minimise the loss of volatile constituents from the samples, a factor which could affect their burning behaviour. The ignition source was a gas flame of constant height burning vertically in a fume cabinet.

Live material was held in a natural position with its lowest part in the ignition source and the rate of flame movement recorded using a stopwatch. The nature of burning was also noted, particularly sparking if present, and patterns of foliage movement in response to heat. To minimise morphological differences, those species with leaves or phyllodes larger than those of <u>Acacia stricta</u> (approximately 2.5cm in length and 0.5cm in width) were analysed after shape standardization undertaken with a razor blade using an <u>A. stricta</u> phyllode as a template. The speed and extent of flame movement was measured for five or more replicates with the standardized photosynthetic organs held vertically above the flame.

The influence of varying moisture contents of photosynthetic organs on the speed and extent of flame movement was tested for a selection of species that covered the range of responses shown in previous tests. Leaves of each species were weighed, then dried to varying degrees in a plant press or oven. Measurements of flame movement and the extent of burning were made with the leaves, phyllodes or cladodes held in the horizontal plane.

The rate and extent of flame movement was measured for five replicates each for the oven-dried fine fuel components. These were held horizontally in the flame in order to approximate their position in natural vegetation.

5.3 RESULTS

5.3.1 Calorimetry

Ranked calorific values (Jg^{-1}), unadjusted and adjusted for percentage ash content, together with their standard error are shown in Table 16. The mean energy levels obtained ranged from 15,974 Jg^{-1} for dead *Poa* sp. leaves to 23,479 Jg^{-1} for dead *Eucalyptus amygdalina* leaves.

Ash-free figures ranged from 18,871 Jg^{-1} for dead *Poa* sp. leaves to 24,247 Jg^{-1} for dead *E. obliqua* leaves. The overall mean of the samples was 20,424 Jg^{-1} unadjusted for ash content, and 21,470 Jg^{-1} ash-free value.

Percentage ash content varied from a high of 15.34% for dead *Poa* sp. leaves to a low of 0.47% for the general category of twigs 1.0-1.5cm in diameter. Percentage silica content for those samples tested ranged from 14% for dead *Poa* sp. leaves to a non-detectable amount in live *E. obliqua* leaves.

TABLE 16: Mean calorific values and their rank, unadjusted and adjusted for ash (parentheses) with standard error (S.E.) for all samples, together with mean percentage ash content and their rank [ ]. All readings are ordered from high to low. % silica content given for selected samples.

GD = dead ground material; GL = live ground material; A/GD = elevated dead material; A/GL = elevated live material.
† Species common in gully scrub and rainforest. NA - no data.

Species/Component	Category	Mean calorific values Jg^{-1}	S.E.	Rank	Mean % ash content		% Si content
Eucalyptus amygdalina - leaves	GD	23,479 (24,231)	37 (36)	1 (2)	3.11	[28]	NA
E. obliqua - leaves	GD	23,325 (24,247)	88 (91)	2 (1)	3.81	[19]	1.90
E. pulchella - leaves	GD	23,209 (23,919)	19 (14)	3 (3)	2.94	[31]	NA
Acacia stricta - leaves	A/GL	23,050 (23,618)	31 (37)	4 (4)	2.39	[35]	0.05
E. amygdalina - leaves	A/GL	22,455 (23,211)	132 (137)	5 (6)	3.23	[25]	NA
Leptospermum scoparium - foliage	A/GL	22,296 (22,896)	114 (118)	6 (11)	2.60	[34]	NA
E. viminalis - leaves	A/GL	22,258 (23,001)	187 (193)	7 (9.5)	3.17	[27]	NA
Exocarpos cupressiformis - foliage	A/GL	22,196 (23,333)	58 (57)	8 (5)	4.86	[17]	NA
E. pulchella -leaves	A/GL	22,163 (23,127)	20 (27)	9 (7)	4.18	[18]	NA
E. obliqua - leaves	A/GL	21,983 (22,659)	75 (69)	10 (13)	3.00	[29]	0.00
Acacia dealbata - foliage	A/GL	21,959 (22,674)	67 (74)	11 (12)	3.28	[24]	NA
Dodonaea viscosa - leaves	A/GL	21,839 (23,001)	9 (14)	12 (9.5)	5.07	[16]	NA
E. globulus - juvenile leaves	A/GL	21,833 (22,546)	70 (76)	13 (14)	3.19	[26]	NA
†*Beyeria viscosa* - leaves	A/GL	21,780 (23,054)	37 (42)	14 (8)	5.49	[15]	NA
†*Olearia argophylla* - leaves	A/GL	20,827 (22,040)	75 (79)	15 (16)	5.50	[14]	1.20
Acacia verticillata - foliage	A/GL	20,763 (21,358)	49 (55)	16 (19)	2.80	[33]	NA
E. obliqua - twigs < 0.5cm	A/GL	20,512 (21,267)	134 (143)	17 (20)	3.52	[22]	NA
†*Atherosperma moschatum* - leaves	A/GL	20,488 (22,209)	1 (9)	18 (15)	7.72	[7]	NA
†*Bedfordia salicina* - leaves	A/GL	20,466 (21,859)	35 (40)	19 (17)	6.39	[11]	0.80

TABLE 16 cont'd

Species/Component	Category	Mean calorific values Jg^{-1}	S.E.	Rank	Mean % ash content		% Si content
Lomandra longifolia - leaves	A/GL	20,429 (21,188)	3 (4)	20 (21)	3.60	[21]	0.40
Gum bark	GO	20,390 (20,796)	106 (107)	21 (24)	1.91	[37]	0.60
amygdalina - twigs <0.5 cm	GO	20,325 (20,781)	44 (39)	22.5 (25)	2.21	[36]	NA
Lomandra longifolia - leaves	A/GO	20,325 (20,704)	183 (187)	22.5 (27)	1.84	[38]	0.08
twigs <0.5 cm Sample 2 (mixed species)	GO	20,188 (20,767)	29 (24)	24 (26)	2.82	[32]	NA
+*Pittosporum bicolor* - leaves	A/GL	20,152 (21,463)	57 (56)	25 (18)	6.06	[12]	0.30
E. amygdalina - twigs <0.5 cm	A/GL	19,933 (20,677)	63 (62)	26 (28)	3.62	[20]	NA
twigs <0.5 cm Sample 1 (mixed species)	GO	19,876 (20,585)	11 (8)	27 (29)	3.44	[23]	0.40
E. pulchella - twigs <0.5 cm	A/GL	19,853 (20,458)	103 (104)	28 (30)	2.98	[30]	NA
twigs 1.0 - 1.5 cm - Sample 1 (mixed species)	GO	19,709 (19,800)	3 (1)	29 (36)	0.47	[41]	NA
Stringy bark	GO	19,554 (19,813)	110 (117)	30 (35)	1.36	[39]	1.10
Pteridium esculentum - foliage	A/GL	19,442 (20,863)	76 (83)	31 (22)	6.77	[9]	NA
twigs 1.0 - 1.5 cm - Sample 2 (mixed species)	GO	19,373 (19,598)	12 (12)	32 (38)	1.12	[40]	NA
Pteridium esculentum - foliage	GO	19,114 (20,273)	105 (111)	33 (32)	5.72	[13]	4.10
Lepidosperma laterale - leaves	A/GO	18,675 (20,801)	111 (126)	34 (23)	10.23	[5]	10.00
Lepidosperma laterale - leaves	A/GL	18,647 (20,004)	71 (71)	35 (34)	6.82	[8]	NA
Gahnia grandis - leaves	A/GL	18,300 (19,591)	41 (43)	36 (39)	6.54	[10]	4.40
Poa sp. - leaves	A/GL	17,931 (20,042)	189 (206)	37 (33)	10.55	[4]	8.40
Gahnia grandis - leaves	A/GO	17,856 (19,608)	40 (43)	38 (37)	8.93	[6]	8.20

TABLE 16 cont'd

Species/Component	Category	Mean calorific values Jg^{-1}	S.E.	Rank	Mean % ash content	% Si content
Diplarrena moraea - leaves	GD	17,850 (20,327)	248 (283)	39 (31)	12.16 [3]	NA
Miscellaneous herbs & forbs	GL	16,612 (19,000)	463 (532)	40 (40)	12.53 [2]	NA
Poa sp. - leaves	A/GD	15,974 (18,871)	37 (31)	41 (41)	15.34 [1]	14.00

Dead eucalypt leaves are the most energy-rich component whether adjusted or unadjusted for ash, with values >23,000 Jg^{-1}. The phyllodes of Acacia stricta have the highest value for live material, exceeding levels recorded for live leaves of Eucalyptus amygdalina, E. pulchella and E. viminalis. These in turn have greater heats of combustion than the live adult leaves of E. obliqua and juvenile leaves of E. globulus.

Acacia stricta, Exocarpos cupressiformis and Leptospermum scoparium have the highest energy levels of the understorey dry sclerophyll species tested. They also have greater energy levels than most species from wetter habitats.

There is a significant inverse correlation at $p = 0.01$ ($r_s = -0.443$) between percentage ash content and calorific value. Ash-free levels highlight differences in energy content which are not immediately apparent from unadjusted levels. The live and dead portions of Lepidosperma laterale are an example, with the dead components being more energy-rich on this basis.

The highest standard error is shown by the live ground material of miscellaneous herbs and forbs and is attributable to the heterogeneity of the sample. However, together with the dead leaves of Poa sp., both unadjusted and ash-free values are significantly less than for the other samples.

The dead leaves of Eucalyptus obliqua, Lepidosperma laterale, Gahnia grandis and Poa sp. have higher ash contents than their live counterparts. The reverse is true for Pteridium esculentum, Lomandra longifolia and E. pulchella. The leaves of E. amygdalina showed no significant differences.

The gum bark sample tested had a greater heat of combustion than stringy bark as well as a slightly higher ash content. The woody components tested showed some degree of variation. Two samples of twigs, 1.0-1.5cm in diameter and of mixed species had slightly differing calorific values and ash contents, but their ranks overall were closely similar. The same is true for the samples of the general category of twigs <0.5cm in diameter. Both ash content and calorific value were slightly greater in the latter category than in the former.

The live twigs (<0.5cm) of the eucalypt species measured had similar energy levels and ash content to the dead twigs <0.5cm in diameter. With the exception of eucalypt leaf litter, dead material was relatively low in calorific content, the twig and bark components all lying in the lower half of the range obtained.

5.3.2 Flammability experiments

Freshly cut material, when held in the natural arrangement over the ignition source had a marked variation in response. *Banksia marginata* responded explosively with rapid flame propagation and spark emission often extinguishing the gas flame. Rapid flaming and propagation were also shown by live and dead *Poa* sp. with the fine arrangement of the leaves and culms providing ample aeration for flame spread. Other self-propagating, but less flammable species were *Eucalyptus pulchella* and *Acacia stricta*. *Leptospermum scoparium*, juvenile *E. viminalis*, *Acacia dealbata*, *A. verticillata* and *Pteridium esculentum* exhibited slower propagation while *E. amygdalina*, juvenile *E. globulus* and *E. obliqua* showed virtually none. *Casuarina stricta*, *Bedfordia salicina* and *Exocarpos cupressiformis* responded by charring only. *Lomandra longifolia* and *Gahnia grandis* only carried the flame where there were dead leaves. Live leaves burnt at the ignition point only and then fell to the ground.

The rates of flame front movement of shape-standardized leaves of a number of wet and dry forest species are shown in Table 17. Three distinct groups emerged after the results for each species had been compared using the Mann-Whitney U Test (M-W: $p = 0.05$) (Fig. 22). Those showing the least propensity to propagate fire were the wet sclerophyll and gully species, Olearia argophylla and Bedfordia salicina, and the rainforest and gully species Atherosperma moschatum. Conversely, the most flammable and self-propagating species were Eucalyptus viminalis adult leaves, Banksia marginata, E. pulchella and Acacia stricta, all of which are characteristic of dry forest (see Chapter 2). The intervening group encompasses a trend of increasing flammability from the least, which were the wet sclerophyll species Beyeria viscosa and Pittosporum bicolor to the most which were E. obliqua, Dodonaea viscosa and E. viminalis juvenile leaves. E. globulus adult and juvenile leaves and E. amygdalina leaves had an intermediate response.

The influence of moisture content on the rate of flame movement for selected species is shown in Fig. 23. The wet sclerophyll and gully species Bedfordia salicina, Olearia argophylla and Atherosperma moschatum had the greatest moisture loss after oven-drying with losses of 65-72% of the initial weight. Dry sclerophyll species Acacia stricta and Banksia marginata showed the least, with maximum losses of 43-46%. Olearia argophylla dried out the most rapidly and Acacia stricta the least rapidly.

Atherosperma moschatum, Olearia argophylla, Bedfordia salicina and the dry sclerophyll species Casuarina stricta required the greatest moisture loss before flaming would occur. A. moschatum showed the greatest resistance with the first flames occurring at about 65% moisture loss, at which combustion was rapid. The fastest rate of spread with oven-dried material was recorded for Bedfordia salicina at 8.02 mms^{-1}. Fast rates of spread were also recorded for A. moschatum (5.88 mms^{-1}) and Olearia argophylla (5.35 mms^{-1}). The least rate recorded for oven-dried material was 1.89 mms^{-1} for Casuarina stricta.

TABLE 17: Rate of flame front movement (mms^{-1}) for replicate live shape-standardized leaves of typical dry and wet forest species.

Species	Rate of flame front movement (mms^{-1})		Comments
	Range	Mean	
Dodonaea viscosa	1.68 - 3.31	2.49	Flames at 90° to leaf.
Beyeria viscosa	1.32 - 2.43	1.86	Rapid flaming at first then slows.
Olearia argophylla	0.80 - 1.09	0.94	Rapid at first then slows. Midrib forms greatest resistance.
Atherosperma moschatum	0.67 - 1.57	1.27	Very slow combustion.
Bedfordia salicina	0.69 - 1.40	1.10	90° flames. Bright glowing. Slight crackles.
Pittosporum bicolor	1.20 - 2.26	1.83	Completely combusts.
Eucalyptus amygdalina - leaves	1.49 - 2.20	1.91	
E. viminalis - juvenile leaves	1.58 - 3.23	2.50	
E. viminalis - adult leaves	2.20 - 3.74	3.15	
E. pulchella - leaves	3.21 - 4.06	3.71	Rapid complete combustion.
E. obliqua - leaves	1.43 - 3.42	2.10	
E. globulus - juvenile leaves	1.33 - 1.57	1.53	Crackles. Resistant to combustion.
E. globulus - adult leaves	1.34 - 2.30	1.89	Crackles. Resistant to combustion.
Acacia stricta	3.03 - 4.95	3.75	Very rapid. Complete combustion.
Banksia marginata	3.13 - 3.41	3.29	Self-propagating. Explosive crackles and sparks.

Increasing rate of flame front spread ↓

Olearia argophylla
Bedfordia salicina
Atherosperma moschatum

Beyeria viscosa
Pittosporum bicolor
Eucalyptus globulus - juvenile leaves
E. globulus - adult leaves
E. amygdalina
Dodonaea viscosa

E. viminalis - juvenile leaves

E. viminalis - adult leaves
Banksia marginata
E. pulchella
Acacia stricta

Fig. 22 : Increasing rate of flame front spread (mms^{-1}) of live shape-standardized leaves or phyllodes.

Dashed lines separate species which are significantly different from each other.

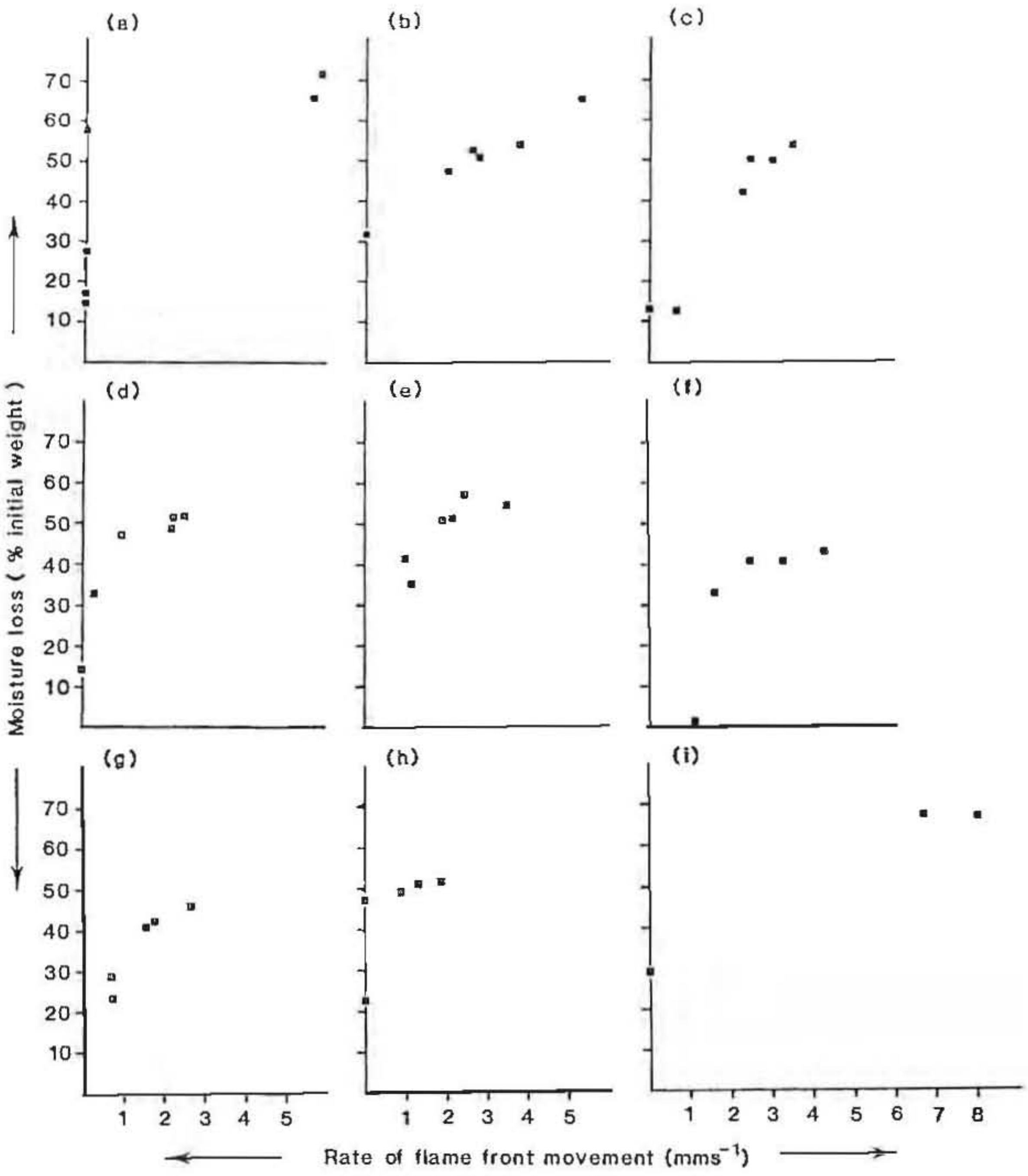


Fig. 23 : The response to ignition of leaves of selected dry and wet habitat species at varying moisture contents.

(a) Atherosperma moschatum;
(b) Olearia argophylla;
(c) Pittosporum bicolor;
(d) Eucalyptus globulus - juvenile leaves;
(e) E. obliqua;
(f) Acacia stricta - phyllodes;
(g) Banksia marginata;
(h) Casuarina stricta;
(i) Bedfordia salicina.

Of the eucalypts tested, juvenile E. globulus leaves were the most resistant to flame propagation, with flaming absent at 14% moisture loss and suppressed to $<1\ mms^{-1}$ until 46% loss. E. obliqua responded more rapidly than did E. globulus until equalising at about 50% loss. Slight increases in the moisture loss of E. obliqua beyond this value resulted in a rapid increase in the rate of flame movement.

Generally species showed relatively large increases in rate of spread for small decreases in moisture content as the oven-dry state was approached.

The rates of flame front movement of typical fine dead fuels from dry sclerophyll habitats are shown in Table 18. Response was varied, with Gahnia grandis having the greatest resistance and the leaves of E. pulchella and E. amygdalina the least. Significance comparisons (M-W) of the dead material reveal four groups which differ significantly at $p = 0.05$ (Fig. 24). Gahnia grandis and Lepidosperma laterale show slow flame spread whereas the most rapid spread is shown by E. amygdalina and E. viminalis leaves.

E. pulchella leaves, gum bark and Lomandra longifolia leaves all have similar responses, with L. longifolia also being similar to stringy bark and E. obliqua leaves. Likewise, Pteridium esculentum bears the greatest similarity to the latter two components (Fig. 24).

5.3.3 Rate of flame front movement and energy content

The rate of flame movement of both live and dead oven-dried material showed a significant correlation with unadjusted calorific content at $p = 0.02$ ($r_s = 0.576$) (Fig. 25). The correlation was less significant ($p = 0.05$, $r_s = 0.506$) when ash-free energy levels were used. However, there was no significant correlation at $p = 0.05$ ($r_s = -0.112$) between rate of flame movement and percentage ash content.

TABLE 18: Rate of flame front movement (mms^{-1}) for replicate oven-dried samples of typical fine, dead fuels in dry sclerophyll habitats GD = dead ground material; A/GD = elevated dead material

Species/Component	Category	Rate of flame front movement (mms^{-1})	
		Range	Mean
Eucalyptus amygdalina - leaves	GD	3.89-4.80	4.33
E. obliqua - leaves	GD	2.67-2.94	2.85
E. pulchella - leaves	GD	3.33-4.11	3.71
E. viminalis - leaves	GD	2.64-4.97	4.48
Lomandra longifolia - leaves	A/GD	3.59-4.40	3.52
Lepidosperma laterale - leaves	A/GD	1.12-2.25	1.67
Gahnia grandis - leaves	A/GD	0.96-1.69	1.41
Pteridium esculentum - foliage	GD	1.87-3.16	2.52
Gum bark	GD	2.93-3.78	3.33
Stringy bark	GD	2.05-3.72	2.64

Increasing rate of flame front spread

Gahnia grandis

Lepidosperma laterale

Pteridium esculentum

Stringy bark/*Eucalyptus obliqua* - leaves

Lomandra longifolia

Gum bark

E. pulchella - leaves

E. amygdalina - leaves

E. viminalis - leaves

Fig. 24 : Increasing rate of flame front spread (mms^{-1}) in selected oven-dried fine (< 0.5cm in diameter) dead fuels.

Dashed lines separate components which are significantly different from each other.

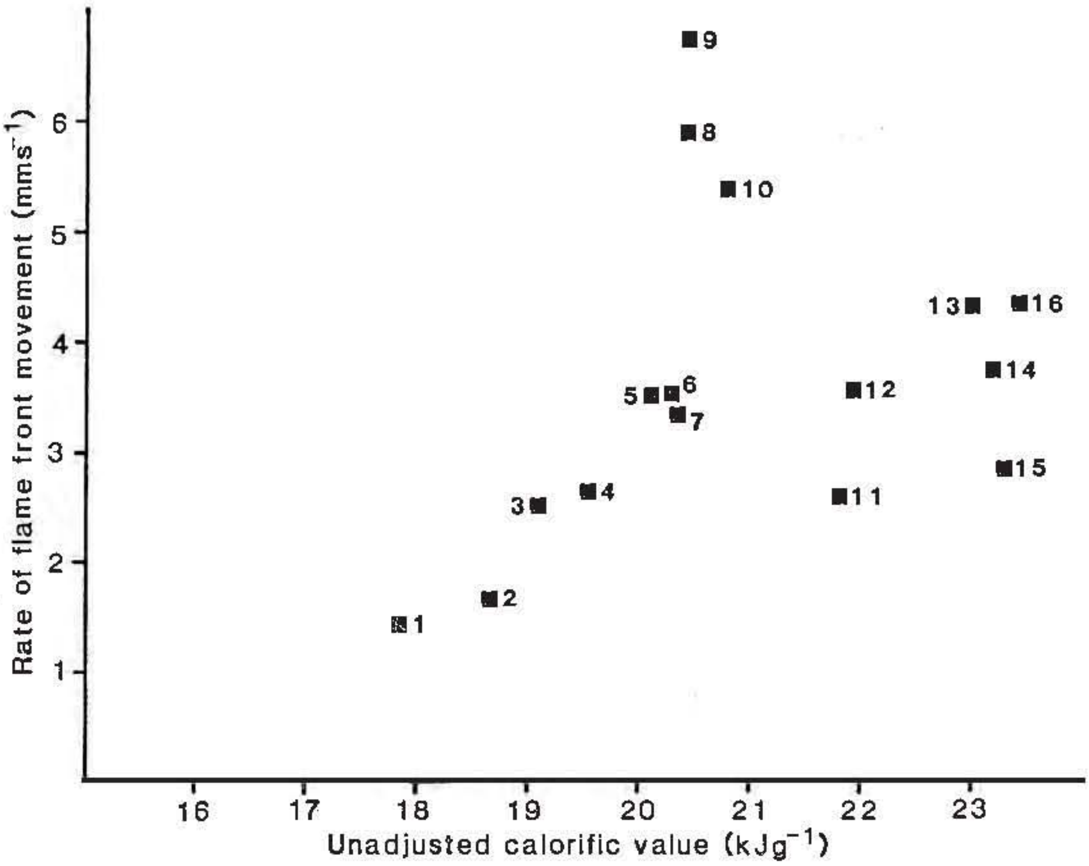


Fig. 25 : Graph showing rate of flame front movement (mms^{-1}) of selected oven-dried components against unadjusted calorific value (kJg^{-1}).

1 = Gahnia grandis A/GD;
2 = Lepidosperma laterale A/GD;
3 = Pteridium esculentum GD;
4 = Stringy bark GD;
5 = Pittosporum bicolor A/GD;
6 = Lomandra longifolia A/GD;
7 = Gum bark GD;
8 = Atherosperma moschatum;
9 = Bedfordia salicina A/GL;
10 = Olearia argophylla A/GL;
11 = Eucalyptus globulus - juvenile leaves A/GL;
12 = E. obliqua leaves A/GL.
13 = Acacia stricta - phyllodes A/GL;
14 = E. pulchella - leaves GD;
15 = E. obliqua - leaves GD;
16 = E. amygdalina - leaves GD.

GD = dead ground material; A/GD = elevated dead material; A/GL = elevated live material.

Observations taken throughout the burning experiments revealed a significant difference (M-W: $p = 0.025$) in percentage ash content between those species that reacted explosively to varying degrees when alight and those that burned silently. The latter species had the highest values.

5.4 DISCUSSION

The range of energy values recorded in this study is larger than that found in tropical forest, or herbaceous and grassland communities, but is similar to documented levels in Mediterranean plant species (Table 19). The absolute values recorded are similar to other published results for related species; 23,422 Jg^{-1} for Eucalyptus obliqua leaf litter (Mutch, 1970) and maximums of 23,675 Jg^{-1} and 21,380 Jg^{-1} for live leaves and leaf litter respectively in variously aged E. tereticornis plantations (Singh, 1980). The present study differs in that eucalypt leaf litter is more energy-rich than live leaves, but concurs with Singh (1980) that energy of leaf litter is greater than that of non-leaf litter.

The inverse relationship between ash content and energy level has also been noted by other workers (Britton et al., 1976). Ash level is suggested to have influence on the pyrolytic properties of a particular species by the impedance of flammability (Broido and Nelson, 1964). Inorganic compounds can produce a catalytic effect which inhibits the formation of combustible volatiles (Shafizadeh, 1968). Philpot (1970) obtained ash contents of 0.01-27.07% in tests of various plant materials and deduced that 0.01-4% was the critical range where small changes in ash content may have a large effect on fuel flammability. Approximately 50% of the present results fall into this range.

TABLE 19: Energy values (Jg^{-1}) in various documented vegetation types and components.

Vegetation type	Energy range (Jg^{-1})	Authority
Tropical forest	16841[1] - 17640[2]	Golley, 1969
Meadow/old field herbaceous comm.	14439 - 18548	Caspers, 1977
Oak/hornbeam herbaceous layer	16059 - 20174	Kubicek, 1977
" " " litter layer	18265 - 21477	" "
Andropogon-Paspalum grassland spp.	15661 - 19221	Britton *et al.*, 1976
" " standing litter	16138 - 17117	" " " "
" " ground litter*	9996 - 16184	" " " "
Californian mediterranean - sclerophyll shrubs	17600 - 21800	Rundel, 1981
Variously aged chamise-chaparral communities	18694 - 20163†	Specht, 1969b
Variously aged garrigue communities	18506 - 19489†	" "
Mediterranean plant species - leaves	17900 - 22800	Heim, 1974
Mediterranean plant species - woody stems	17900 - 21500	" "
Mediterranean plant species - aerial parts	15700 - 21500	" "

[1] Litter ± 130 [2] Boles ± 59

* Large amount soil contamination

† Mean figures for specific age community

A representative selection of species and components showed that those with the highest ash fractions also had appreciable silica content. Silica however, is of little or no importance in pyrolysis (Mutch and Philpot, 1970), therefore silica-free ash contents for a selected range of samples are presented in Table 20. Those with the highest values are the wet habitat species Pittosporum bicolor, Bedfordia salicina and Olearia argophylla.

However, silica may be important in the impedance of litter decomposition and the accumulation of fuel (Mutch and Philpot, 1970). High silica content species, notably Poa sp., Gahnia grandis, Diplarrena moraea, Lepidosperma laterale and Pteridium esculentum all have growth forms that result in the intermixing of live and dead material. Retention of fine dead fuel within the plant structure has been observed in other Australian species such as Xanthorrhoea australis (Specht et al., 1958) and Eucalyptus macrorhyncha (Moore and Keratis, 1971). Sampling within Gahnia grandis tussocks during the fuel collection described in Chapter 4 produced quantities of dead eucalypt twigs and leaves caught in the central structure. Poa sp. retains large amounts of fine, dead and cured leaves and culms within the tussock structure for long periods. This fine material provided one of the most flammable arrangements encountered in the present study although individual leaves showed little evidence of flame propagation when tested. This is a reflection of the low biomass and calorific content of each leaf, once lit, only a small flame was maintained with correspondingly low heat emission. The response to radiation in advance of the flame front was therefore also low.

Ash content may be reduced by leaching (Broido and Nelson, 1964), although the reduction is likely to be selective. Attiwill (1968) demonstrated that certain elements were removed by leaching but others were lost only as material decomposed. Philpot (1970) showed that the maximum volatilization rate was highly correlated with the phosphorous and calcium content of particular fuels. This is disputed by Mak (1982)

TABLE 20: Percentage silica-free ash content for representative wet and dry habitat species/components.

GD = dead ground material; A/GD = elevated dead material; A/GL = elevated live material.

Species/Component	Category	Si-free ash content (%)
Pittosporum bicolor - leaves	A/GL	5.76
Bedfordia salicina - leaves	"	5.59
Olearia argophylla - leaves	"	4.30
Lomandra longifolia - leaves	"	3.20
twigs <0.5 cm diameter	GD	3.04
Eucalyptus obliqua - leaves	A/GL	3.00
Acacia stricta - phyllodes	"	2.34
Poa sp. - leaves	"	2.15
Gahnia grandis - leaves	"	2.14
E. obliqua - leaves	GD	1.91
L. longifolia - leaves	A/GD	1.76
Pteridium esculentum - foliage	A/GL	1.62
Poa sp. - leaves	A/GD	1.34
Gum bark	GD	1.31
G. grandis - leaves	A/GD	0.73
Stringy bark	GD	0.26
Lepidosperma laterale - leaves	A/GD	0.23

who, in a study of nutrient- flammability relations in some Australian species, maintained that there was little justification for a direct relationship between nutrient concentrations and flammability. Live Eucalyptus obliqua leaves have a higher ash content than dead leaves of the same species. However, the converse is true for Pteridium esculentum foliage and E. pulchella leaves. Ash content of litter fractions may be influenced by contamination by soil particles. Also there may be some intraspecific variation as well as variation attributable to stage of plant development.

The relative non-flammability of live portions compared to the dead in particular species has implications for plant survival. For example, Lepidosperma laterale cures from the leaf tip first. Flames carried by this material are extinguished by the living tissue, so protecting the live portion of the plant.

Not all the dry sclerophyll species showed high rates of flame spread in live material. However, Banksia marginata, Acacia stricta, Eucalyptus pulchella and Poa sp. emerged as the four most flammable species. Growth morphology was of obvious importance with such species as Exocarpos cupressiformis whose large number of very fine leaves growing in close arrangement exclude oxygen and therefore inhibit flame spread. Conversely, the curled, well aerated arrangement of Pteridium esculentum enhances flame movement even though small individual portions of the plant are not particularly flammable. P. esculentum is often the dominant regrowth in well drained areas following fire in dry sclerophyll habitats (see Chapter 2). The rapid production of dead and cured material produces a high and well-aerated fuel load (see Chapter 4).

Sections of stringy bark had a slower rate of flame front spread than decorticating gum bark but this varied according to the configuration of the sample. The curled nature of gum bark funnelled the flame, whereas the fibrous stringy bark burned more slowly but retained glowing combustion for longer. Gill and Ashton (1968) showed that fibrous bark was more flammable than decorticating bark. The penetration of heat was greatest in loose, dry fibrous bark (Gill and Ashton, 1968; Vines, 1968). However, decorticating gum bark species are important in the spot fire mechanism (Mount, 1964).

The shape-standardized leaf experiment highlighted differences between eucalypt species which cannot be attributed solely to leaf configuration. Eucalyptus globulus leaves, both juvenile and adult, presented the greatest resistance to flame spread of all the eucalypts studied. In this case, leaf thickness was important (cf. Montgomery and Cheo, 1971), as well as the presence of a thick waxy cuticle.

High moisture levels have long been recognised as promoting partial combustion and smoke formation (Byram, 1959). Smoke restricts the supply of oxygen and the presence of water decreases radiant heat emission. The moisture content of the wetter habitat species Olearia argophylla, Bedfordia salicina and Atherosperma moschatum are higher than for dry sclerophyll species (also noted by Mount, 1964) but flame propagation is rapid once a critical threshold of moisture loss is crossed. Pittosporum bicolor was the most flammable of the gully species tested but lacked the obvious volatile oil content found in the leaves of the dry sclerophyll species. Essential oils have a high energy content (Pompe and Vines, 1966) and tend to be concentrated in foliage tissue (Rundel, 1981), which is reflected in the high calorific values of the highly flammable eucalypt leaves and Acacia stricta phyllodes. Rundel (1981) quotes chaparral vegetation where live fuels with volatile oils may burn at 100% of their maximum moisture content whereas dead material will not burn above 20-30%. Volatile oils are especially important in the early stages of burning when their presence will encourage combustion. Baker and Smith (1902) showed that Australian eucalypts have oil contents ranging from 1-4% whilst Mak (1982) recorded levels as high as 22.77% for ether extractives in young E. fastigata leaves.

The results generally support the Mount, Jackson and Mutch hypothesis with species from the least-burned communities showing the least tendency to propagate fire.

The *Atherosperma*-dominated gully communities gain fire protection from physiologically-specific attributes which discourage flame spread. *A. moschatum* leaves have high moisture and ash contents, a waxy, fire-resistant cuticle on both lamina and midrib and a low volatile oil content.

At the opposite end of the habitat moisture gradient are the dry communities dominated by *Eucalyptus* or *Casuarina*. Of these, only those communities dominated by *Casuarina* are at all likely to be destroyed by burning. In contrast, those dominated by eucalypts can be destroyed by the absence of fire (Withers and Ashton, 1977). *Casuarina stricta* was the least flammable of the dry sclerophyll species tested in the moisture loss experiment. The low biomass of each leaf produced only a small flame, as in the case of *Poa* sp. leaves. However, rapid flaming resulted when dead material was held vertically. Thus *Casuarina* litter is relatively non-flammable although fire will carry in the well-aerated, vertically hanging, above-ground biomass.

The understorey species from wet sclerophyll forests do not encourage fire to the same degree as those in dry sclerophyll forests. Understorey wet sclerophyll species have high percentages of moisture and ash whereas those from dry sclerophyll forests have in general, low ash contents, high energy levels, high volatile oil contents and low moisture contents.

Thus any fire regime, planned or otherwise, that results in the substitution of wet sclerophyll species by dry sclerophyll species is likely to increase the flammability of the forest.

CHAPTER 6

SLASH-BURNING AND FOREST MANAGEMENT

6.1 INTRODUCTION

Slash-burning in current dry forest management practice is used mainly to reduce the fire hazard left following logging (see Chapters 1 and 4). However, each burn results in the loss of natural regeneration with a consequent immediate loss in eucalypt productivity, and site-specific eucalypt genotypes (Chapter 2). In addition, there is concern over the long-term site deterioration and nutrient depletion that may be involved with hot regeneration burns (Chapter 1). Therefore, the pertinent questions in terms of forest industry management are:

1) for how long does slash-burning effectively reduce fire hazard on a site?;

2) does slash-burning result in enhanced growth of the regenerating stand compared to equivalent unburnt sites?;

3) if a site is left unburnt, what productivity losses due to wildfire may be expected before the next harvest, compared to the expected losses on a site which has been slash-burnt?;

4) how do these productivity losses compare to the productivity gained from the advanced growth which is present following the first harvest in the unburnt situation?

This chapter examines these questions with reference to the results reported in Chapters 2 to 5.

6.2 SLASH-BURNING IN RELATION TO FIRE HAZARD

Following clearfelling in dry forests there are marked variations in the growth response of plant species due to environmental situation, degree of disturbance, intensity of slash-burn (Chapter 2), and selective grazing and browsing (Chapter 3). The results reported in Chapters 2 and 3 also demonstrated that burning favours unpalatable species that recover rapidly by vegetative means. In many instances these species are highly flammable (Chapter 5). Within two years of slash-burning there is a rapid production of live and dead herbaceous vegetation, resulting in a well-aerated fuel load, the levels of which may equal or exceed those on unburnt sites (Chapter 4). The ground fine fuel load remains greater on unburnt treatments than on equivalent burnt sites for at least 9 years following clearfelling in types P and O, and for at least 8 years in type D/O (Chapter 4). Compacted ground fuel can contribute to fire intensity (cf. Mount, 1979) depending on its moisture content, but will not affect the actual incidence of fire, which in Tasmania is predominantly of human origin (Jackson and Bowman, 1982).

Given the weather conditions under which most severe fires occur in Tasmania, that is high winds, high temperatures and low humidity, it is probable that enough fuel of sufficient continuity is present in 3 to 5 year-old regeneration to carry a fire which is difficult to control. In the period 1979-1984 unplanned dry forest fires in State Forest occurred in artificial regeneration aged 7 years, and in one instance a back-burn was possible in 2 year-old regrowth. On wetter sites wildfires occurred in regeneration of ages 2 to 10 years (Forestry Commission, Tasmania, unpublished). Under conditions of high fire danger regrowth in type O communities is likely to present a greater fire hazard than that in type P, with fuel loads tending to be greater and more continuous in type O. However, it is probable that there would be a larger grass component in the species occurring in type P communities than in those occurring in type O. The resulting fuel assemblage on some type P sites can be extremely flammable, being capable of carrying and maintaining rapid flame front movement (Chapter 5) only a few years after slash-burning. In both type P and type O, the vagaries of wildfire behaviour can result in some regeneration escaping fatal damage, and as such this regrowth may continue as a population cohort within the regenerating forest (Duncan, 1981a).

6.3 PRODUCTIVITY GAINED BY THE REGENERATING STAND WITH AND WITHOUT SLASH-BURNING

Slash-burning, particularly where there is intense fire, can enhance eucalypt seedling establishment and regeneration in some forest types (see Chapter 1). The results presented in Chapter 2 showed that where the establishment of eucalypt seedlings did occur at MM14, the favoured areas in type O communities were those of high intensity burn which had not been severely baked, where species having rapid vegetative propagation did not gain dominance in the first few months following slash-burning. In addition, establishment occurred on mechanically disturbed sites which had not suffered excessive compaction, but that the majority of the disturbed area was made unavailable for that reason. The favouring of areas which had experienced high intensity burn or mechanical disturbance was not obvious in type P. In both vegetation types a substantial proportion of the eucalypt regeneration consisted of individuals which escaped death during the logging and slash-burning. Two year-old advanced regeneration on unburnt sites in types P and O, generally did not differ from 5 year-old burnt, artificially regenerated stands in terms of height and basal area (Table 7: Chapter 2). Density of regrowth varied from site to site. In type D/O eucalypt height was greater in unburnt regeneration than in equivalent artificially sown stands for at least 8 years after fire. However, in this case the position is complicated by the fact that the unburnt sites were originally exempt from slash-burning because of the presence of high quality regrowth.

A productive forest industry is not necessarily based on high density eucalypt regeneration. The productivity of a stand may be acceptable over a range of tree densities, as has been noted by Assmann (1970) for various Northern Hemisphere tree species. Nevertheless, little is known of the optimum tree density for maximum eucalypt productivity. However, from the viewpoint of forest industry, the height of the tallest stems recorded at each of the random points used in the point-centred quarter method described in Chapter 2, may provide a better indication of successful eucalypt regeneration than the mean heights calculated from all the eucalypts measured (see Table 7). The median heights of the tallest stems recorded on treatment UB at MM14, and in the artificial regeneration at MM20 and TO2 are given in Table 21, together with the levels of significance (M-W) of the differences between the height of the advanced growth at MM14, and the height of the other ages of regrowth in vegetation types P and O. Type O regrowth at MM14 was significantly taller than 5 year-old stems at MM20. However, the height of the regrowth in type P did not differ at p = 0.05 between the advanced regeneration at MM14 and the age 5 regrowth, and was only weakly less (p = 0.05) than the 9 year-old stems.

Eucalyptus obliqua is the dominant eucalypt on type O sites (Chapter 2). The species produces high quality timber of potential sawlog standard. From the results recorded at MM14 it appears that the advanced growth on the more mesic sites has a greater height advantage over 5 year-old artificial regeneration than on the drier, well-insolated positions where the pulpwood tree, E. pulchella, dominates. It is possible that eucalypt stems present on type O sites may have an 8 to 9 year overall advantage compared to regrowth on equivalent areas which have been slash-burnt. This consideration is of particular importance when managing a forest for both pulpwood and sawlog quality timber. Production of sawlog timber takes place at a slower rate than the production of timber which is merchantable as pulpwood, and as a consequence trees have little chance of reaching sawlog standard within forest managed for pulpwood over short rotation cycles of 40 to 50 years (Kirkpatrick and Bowman, 1982). Some suggestion has been made that thinnings of stems of pulpwood standard could be made within a longer rotation cycle with the aim of ultimately achieving a sawlog quality product (Felton and Cunningham, 1971; A. Goodwin, personal communication). However, current management practice implies

TABLE 21 : Median values of the height of the tallest stem (cm) recorded at each of the random points used in the point-centred quarter method described in Chapter 2, on treatment UB, MM14 and the coupes MM20 and TO2.

* Significant at level p = 0.02; † significant at p = 0.05; NS not significant at p = 0.05

adv. = advanced natural regeneration.

Coupe	Regrowth age	Treatment	Vegetation type	Median height of tallest stem (cm)
MM14	adv.(2)	UB	P	147
			sig. level	NS
MM20	5	B	P	133
MM14	adv.(2)	UB	P	147
			sig. level	†
TO2	9	B	P	201
MM14	adv.(2)	UB	O	225
			sig. level	*
MM20	5	B	O	104
MM14	adv.(2)	UB	O	225
			sig. level	NS
TO2	9	B	O	248

that there will be no separate harvests of pulpwood (K.C. Felton, personal communication).

6.4 PRODUCTIVITY LOSSES BETWEEN FOREST HARVESTS DUE TO WILDFIRE

To illustrate the effect of unplanned fires on eucalypt productivity between successive forest harvests, a simple model was developed using a set of assumptions based on conclusions drawn from the results contained in Chapters 2 to 5. Absolute values used in these assumptions were varied in an attempt to quantify their influence on productivity loss.

Assumption 1: Slash-burning results in a period where there is insufficient fuel to carry a fire, and as a consequence during this time regenerating eucalypts are protected from destruction by burning. The fire protection period will vary spatially depending on environmental and community characteristics but is assumed to last for between 3 and 7 years.

Assumption 2: There is a yearly probability that fire will occur in dry forests.

To establish this probability, data on unplanned fires occurring in State Forest, inclusive of all forest types, and in dry forest communities occurring in all categories of land tenure, as well as in State Forest, were obtained for the period 1979-1984 (Forestry Commission, Tasmania, unpublished). These data were combined with the total area figures derived from Kirkpatrick and Dickinson (1984) (see Table 1) to obtain the percentage of the total area belonging to the particular forest type and land tenure, which had been burnt during the 5 year period (Table 22). The data showed that over this timespan dry forests in State Forest were burnt by unplanned fires at a rate of 2.5% per year, which was in excess of the rates recorded in other types of forest or land tenure. However, the rate of burning in dry forests in

	Area burnt (ha) 1979-1984	% of total area, burnt 1979-1984	Number of fires 1979-1984
All forest types in State Forest	91,981	7.8	853
Dry forest in all land tenure categories	109,712*	6.7	NA
Dry forest in State Forest	66,776	12.5	340

TABLE 22 : The number of unplanned fires, the area burnt (ha), and the percentage of the total area covered by the particular forest type or land tenure which was burnt during the years 1979-1984. Figures for total area were derived from Kirkpatrick and Dickinson (1984) (see Table 1).

*The area burnt does not include hazard reduction burns on private property.

all land tenure categories (1.3% per year: Table 22) is deceptively low due to the exclusion of data on hazard reduction burns on private property. These burns can cover large areas. Consequently the probabilities that wildfire will occur in dry forest were assumed to be between 2.5% and 10% per year.

Assumption 3: Dry forests accrue sufficient merchantable timber to allow them to be harvested over a particular rotation cycle.

Bowman and Jackson (1981) quote possible rotation cycles of 40 and 50 years from Forestry Commission documentation, with the additional proviso that these time periods are open to amendment. Jackson and Bowman (1982) prefer to consider 80 years as a reasonable production cycle in dry forests. The harvest rotation cycles currently proposed are of 80 to 90 years duration (K.C. Felton, personal communication). Thus for the purposes of this study it was assumed that dry forests are harvested on a 40 year through to an 80 year rotation cycle.

Assumption 4: Eucalypt productivity in dry forests on slash-burnt sites is equal to the productivity on sites left unburnt.

For the purposes of the present study, productivity was assumed to be $5m^3$ per hectare per year (the absolute value is unimportant as the term is common to both the numerator (loss in productivity) and the denominator (total potential productivity over a complete rotation cycle) used in subsequent calculations of the percentage of the total productivity that is lost due to wildfire).

Assumption 5: Any areas which are burnt by wildfires are subsequently artificially sown. Regeneration on these areas grows at the same rate of productivity as stated in Assumption 4.

The percentage loss in productivity over a particular rotation cycle which is sustained by a site left unburnt at the first harvest compared to a slash-burnt site, was calculated as follows.

In the first year of the fire protection period the slash-burnt area will not carry fire, whilst the unburnt area (A_o) will be burnt with a wildfire probability of Wfp. The proportion of the original unburnt area (A_o) that will be burnt is thus A_o x Wfp. Therefore, the remaining area left unburnt (A_1) will be

$$A_1 = A_o - A_o \text{ Wfp} \qquad (1.1).$$

In the second year of fire protection the slash-burnt area will not carry fire, whilst the remaining unburnt area will be burnt with the wildfire probability Wfp. At the end of the second year the area still left unburnt (A_2) will be

$$A_2 = A_1 - A_1 \text{ Wfp} \qquad (1.2)$$

and similarly, at the end of the third year the area left unburnt (A_3) will be

$$A_3 = A_2 - A_2 \text{ Wfp}$$

In the first year the area burnt will constitute a loss in productivity of

$$k \, (A_o \text{ Wfp})$$

where k = the annual productivity (m^3 per hectare).

In the second year, the area burnt will constitute a 2 year loss in productivity compared to a fire protected site, the latter having been able to regenerate in the absence of wildfire for those 2 years. Thus, the cumulative productivity loss over the 2 years will be

$$k(A_o\ Wfp) + 2k(A_1\ Wfp)$$

and similarly, over 3 years the cumulative loss in productivity will be

$$k(A_o\ Wfp) + 2k(A_1\ Wfp) + 3k(A_2\ Wfp) \qquad (1.6)$$

and so on.

Once the fire protection period for the slash-burnt site has elapsed, then this artificially sown site will await fire under the same conditions of probability as experienced by the unburnt site. Thus, the loss in productivity sustained over the complete rotation cycle by the stand regenerated without burning compared to the slash-burnt site, will occur during the years covered by the fire protection period.

Over a complete rotation cycle

$$K = k\ A_o\ R \qquad (1.7)$$

where K = the total productivity possible (m^3) and R = the length of the rotation cycle (years).

Combining equations 1.6 and 1.7, the percentage loss in productivity over the complete rotation cycle (R), of the original unburnt site compared to a slash-burnt site having a 3 year fire protection period, will be

$$\frac{k(A_o\ Wfp + 2A_1\ Wfp + 3A_2\ Wfp)}{K} \times 100$$

$$= \frac{(A_o\ Wfp + 2A_1\ Wfp + 3A_2\ Wfp)}{A_o\ R} \times 100$$

By substituting equations 1.1 and 1.2, the percentage loss in productivity (L) will be

$$\frac{6\ Wfp - 8\ Wfp^2 + 3\ Wfp^3}{R} \times 100$$

In general, after n years

$$L(n) = k\ A_o\ Wfp \sum_{j=1}^{n} j(1 - Wfp)^{j-1}$$

and as n approaches infinity

$$\lim_{n \to \infty} L(n) = \frac{k\ A_o}{Wfp}$$

The convergence is fast for $Wfp > 0.5$, and slow for $Wfp < 0.5$ (D.G. Green, personal communication).

Table 23 and Fig. 26 express the percentage loss in productivity compared to the total productivity possible, that is sustained by the unburnt site under the assumptions 1 to 5, with varying absolute values of rotation cycle, fire probability and fire protection period. The estimated loss varies from a high of 4.7% of the total productivity possible over a 40 year rotation cycle, with a 10% probability of fire occurring each year, and a 7 year fire protection period afforded to an equivalent slash-burnt site; to a low of 0.2% over an 80 year rotation cycle, with a 2.5% probability of fire incidence, and a 3 year fire protection period. Under a 7 year fire protection period with the same rotation cycle and probability of fire occurring as in the latter case, the percentage loss is 0.7%.

The percentage loss in productivity decreases in a curvilinear fashion with increasing length of rotation cycle (Fig. 26). This reduction in percentage productivity loss is more pronounced for the curves corresponding to the 7 year fire protection period (FPP) than for those representing the 3 year fire protection period. The decrease in

Percentage of total area burnt each year	40 year rotation cycle			80 year rotation cycle		
	Total potential productivity (m^3/100ha) over rotation cycle	Fire protection period (years)		Total potential productivity (m^3/100ha) over rotation cycle	Fire protection period (years)	
		3	7		3	7
		Productivity loss m^3/100ha			Productivity loss m^3/100ha	
2.5	20,000	73(0.4)	272(1.4)	40,000	73(0.2)	272(0.7)
5.0	20,000	140(0.7)	572(2.9)	40,000	140(0.4)	572(1.4)
10.0	20,000	262(1.3)	934(4.7)	40,000	262(0.7)	934(2.3)

TABLE 23: The loss in eucalypt productivity (m^3/100ha) under varying incidence of fire over 40 and 80 year harvest rotation cycles on unburnt clearfelled sites compared to burnt sites, assuming a 3 or 7 year fire protection period for the artificially regenerated stand. Productivity is calculated on the basis of $5m^3$ per hectare per year. Values are given to three significant figures.

Figures in parentheses correspond to the percentage of the total potential productivity that is lost. Values are given to one decimal place.

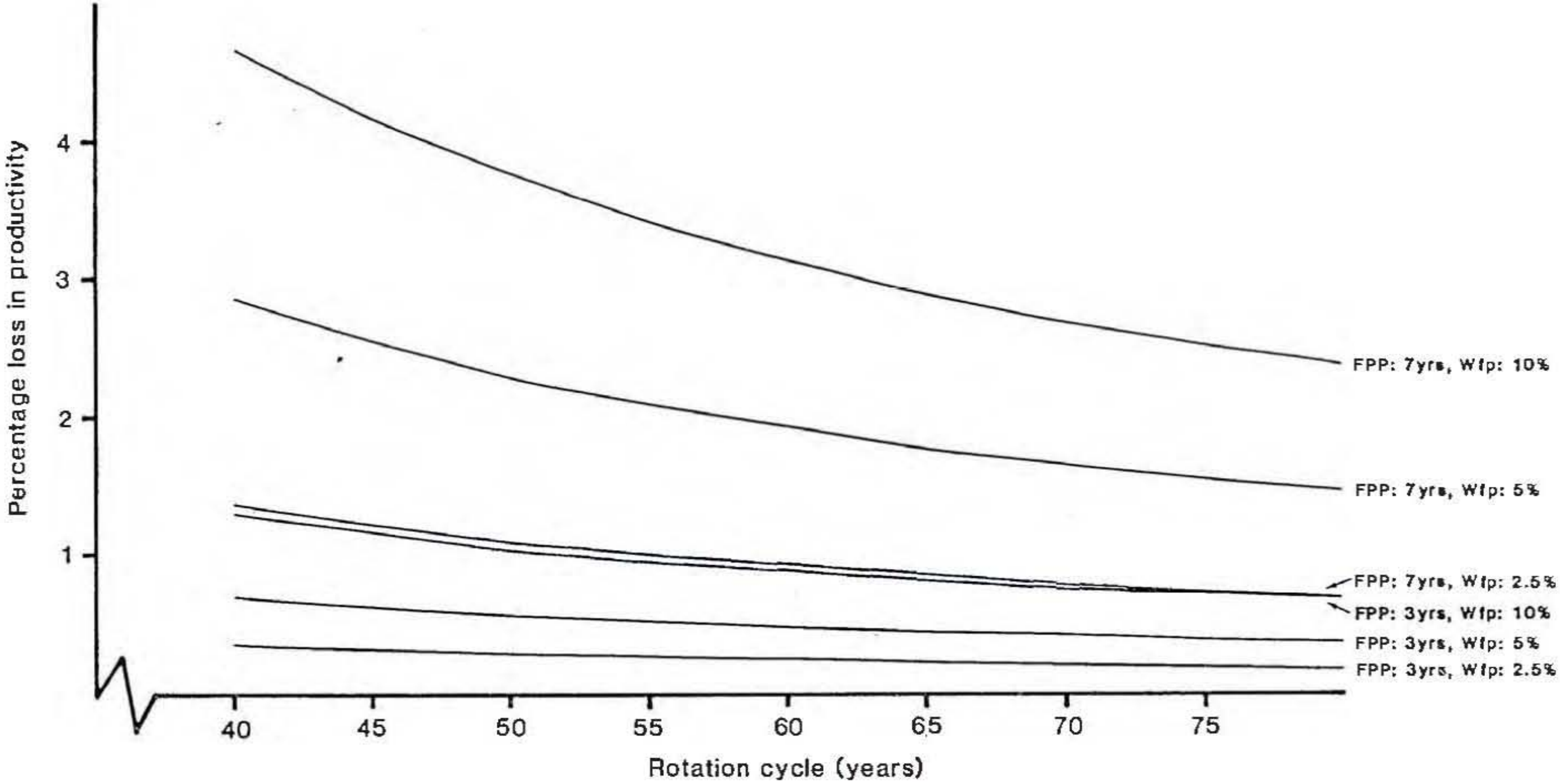


Fig. 26 : The percentage loss in productivity over particular rotation cycles of an unburnt clearfelled site compared to an equivalent slash-burnt site for varying fire protection periods (FPP) and yearly probabilities of wildfire occurring (Wfp).

percentage productivity loss proceeds at a greater rate if the rotation cycle is increased from 40 to 60 years than if the cycle is taken from 60 to 80 years (Fig. 26).

6.5 SLASH-BURNING AND DRY FOREST MANAGEMENT

Current forest management practice in dry forests involves clearfelling followed by slash-burning and aerial sowing of seed. The regenerating forest is then allowed to grow in the absence of fire for 15 years, after which fuel levels present under the eucalypt stand are to be reduced by prescribed burning. Thereafter, fuel accumulations in the forest are to be reduced by burning every 10 years (Mount, 1969). In stands of age 15 which have not been regenerated by slash-burning, the fuel load is perceived as presenting an unacceptable risk in terms of potential damage to the eucalypt crop during prescribed burning operations (Forestry Commission, Tasmania, 1982, unpublished). Prescribed burning is recognised to be impractical in regrowth aged less than 15 years due to the close proximity of live eucalypt fuels to the ground, and the consequent risk of damage to the crop. Slash-burnt areas are also viewed as functional fire-breaks, the presence of which will reduce the risk of wildfire spreading into adjacent unlogged forest or young regenerating stands. Wildfire in unlogged forest may not result in the death of the stand but instead can lead to the downgrading of timber from sawlog to pulpwood standard. This deterioration in quality can emerge as a substantial loss in capital return from the merchantable crop. Financial losses are also incurred during wildfire suppression, which absorbs both capital and labour resources.

From the results and discussions presented in this thesis it is apparent that the practice of slash-burning engenders advantages and disadvantages. The species comprising the dry forest community are resilient to fire but vary in their response to particular fire intensities (Chapter 2). The combination of burning and increased predation following the fire leads to a shift in dominance of the understorey species (Chapters 2 and 3). Slash-burning does induce a fire protection period for the regenerating stand, but the length of the period will vary with environmental situation. In many cases, the period will not exceed 3 years. Prescribed burning in 15 year-old regrowth will present a similar degree of difficulty in stands regenerated with and without slash-burn management, in terms of acceptable weather conditions for burning and control of the operation. The particular fine fuels that develop after slash-burning, notably live and dead herbaceous vegetation, together with the decomposing coarse fuels that still remain regardless of the original regeneration burn, will provide a fuel combination of high fire hazard after 15 years.

If the advanced growth on unburnt sites has a greater than three year age advantage over equivalent burnt treatments it is dubious whether slash-burning will induce a justifiable productivity gain in the eucalypt crop from one harvest to the next. The percentage loss in productivity of an unburnt stand compared to one which has been slash-burnt is likely to be less than 1% of the total productivity possible over rotation cycles of 60 to 80 years with realistic levels of probability that wildfire will occur (i.e. Wfp = 2.5% per year: Fig. 26). Given that slash-burnt areas act as a barrier to fire, the wildfire probability experienced by nearby unburnt sites may be affected. Even taking this consideration into account by doubling the probability that wildfire will occur in unburnt treatments, the total productivity lost over 60 to 80 year rotation cycles remains less than 1% with a 3 year fire protection period (Wfp = 5% per year: Fig. 26). Moreover, the sawlog potential of a particular clearfelled treatment is likely to be enhanced by the absence of hot slash-burns.

The question of the deterioration in the quality of regrowth or mature forest adjacent to burnt and unburnt treatments which may occur following wildfire, remains difficult to address. Burnt treatments may protect nearby sections of unlogged forest during the fire protection period but on days of high fire danger the likelihood of fires spotting in advance of a flame front is substantial. The chance of a fire extinguishing itself at the boundary of a slash-burnt treatment during the requisite fire protection period appear slight, as fire could skirt the uncut forest margins. Some attempt has been made to model fire spread using some forests in the United States as the case study (e.g. Rothermel, 1972) but there have been few attempts to model the practicalities of the Australian situation, with the attendant fuel assemblages, fuel structure and fuel composition, and conditions of severe fire danger.

If a clearfelled treatment has very poor advanced growth then slash-burning is probably the best way of reducing competition to provide the chance for successful eucalypt regeneration, provided that sowing of seed occurs soon after burning. Other methods of preparing suitable seedbeds involving large-scale mechanical disturbance such as with the use of bulldozers, large brushrakes, and ball and chain crushing, will most likely result in greater ecological damage within dry forest communities, the plant species of which are adapted to fire rather than to physical upheaval. On this basis, there seems no reason to suggest a policy of total fire exclusion in dry forest management. A system of hazard reduction burns involving fires of variable intensity and patchy distribution, and of differing fire-free interval will maintain floristic variation (cf. Loyn et al., 1983). However, too frequent burning will favour those species best adapted to regenerate and compete in that particular fire regime (Gill, 1977; see also Chapter 5), and could increase, rather than decrease, forest fire hazard.

CHAPTER 7

THE EFFECTS OF CLEARFELLING ON THE DISTRIBUTION OF BIRD SPECIES

7.1 INTRODUCTION

The lack of data regarding the effects of clearfelling on wildlife has been emphasised by Conner and Adkisson (1975) for North America, and by Statham (1984) for Australia. Fauna vary in their ability to withstand the disturbance, the most severely affected being those vertebrates and invertebrates which are dependent on mature trees for feeding and breeding (Franzreb, 1977; McIlroy, 1978; Recher et al., 1981).

In Australia, information pertaining to the impact of forest utilisation on the avifauna is more extensive than for other vertebrate groups (e.g. Cowley, 1971; Pattemore and Kikkawa, 1975; Woinarski, 1979; Loyn, 1980; Pattemore, 1980), probably because birds are easier to study on a regular basis (Statham, 1984). There are very few data on the effects of clearfelling on mammals or invertebrates.

Clearfelling dramatically truncates the vertical vegetation structure of the natural forest (Chapter 2). Consequently, wildlife which can exploit open ground for both feeding and breeding tends to be the least affected in the first few years following cutting (Conner and Adkisson, 1975; Loyn et al., 1980; Pattemore, 1980). As the forest regenerates, birds have been observed to follow a succession in which different species become abundant as the structural diversity of the vegetation increases (Green, 1980; Franzreb, 1977; Loyn et al., 1980; Pattemore, 1980).

The effect on fauna of forest management which involves the use of fire has received some attention. The influence of prescribed burning (generally involving fires of low to medium intensity) under mature or regenerating stands has been considered by Cowley et al. (1969), Leonard (1970), Cowley (1971), Christensen and Kimber (1975), and McIlroy (1978). Fuel reduction burning affects bird species which feed and nest on the ground (Cowley, 1971) but little is known of the impact on wildlife of fires of different frequency, or of fires which occur at particular times of the year (McIlroy, 1978). Study into the effects of the hot, intense fires associated with slash-burning has been largely neglected (Pattemore, 1980).

This chapter seeks to investigate the short-term effects of clearfelling and slash-burning, on wildlife within dry forests. Due to the limited amount of time available within the framework of the studies described in Chapters 2 to 5, a survey of the bird population was chosen as a means of giving some indication of the sensitivity of wildlife to habitat change. The following questions were addressed:

1. How does clearfelling in dry forests affect bird species composition and abundance?;

2. Does the combined disturbance of clearfelling and slash-burning restrict bird species composition and abundance to a greater degree than disturbance following logging alone?

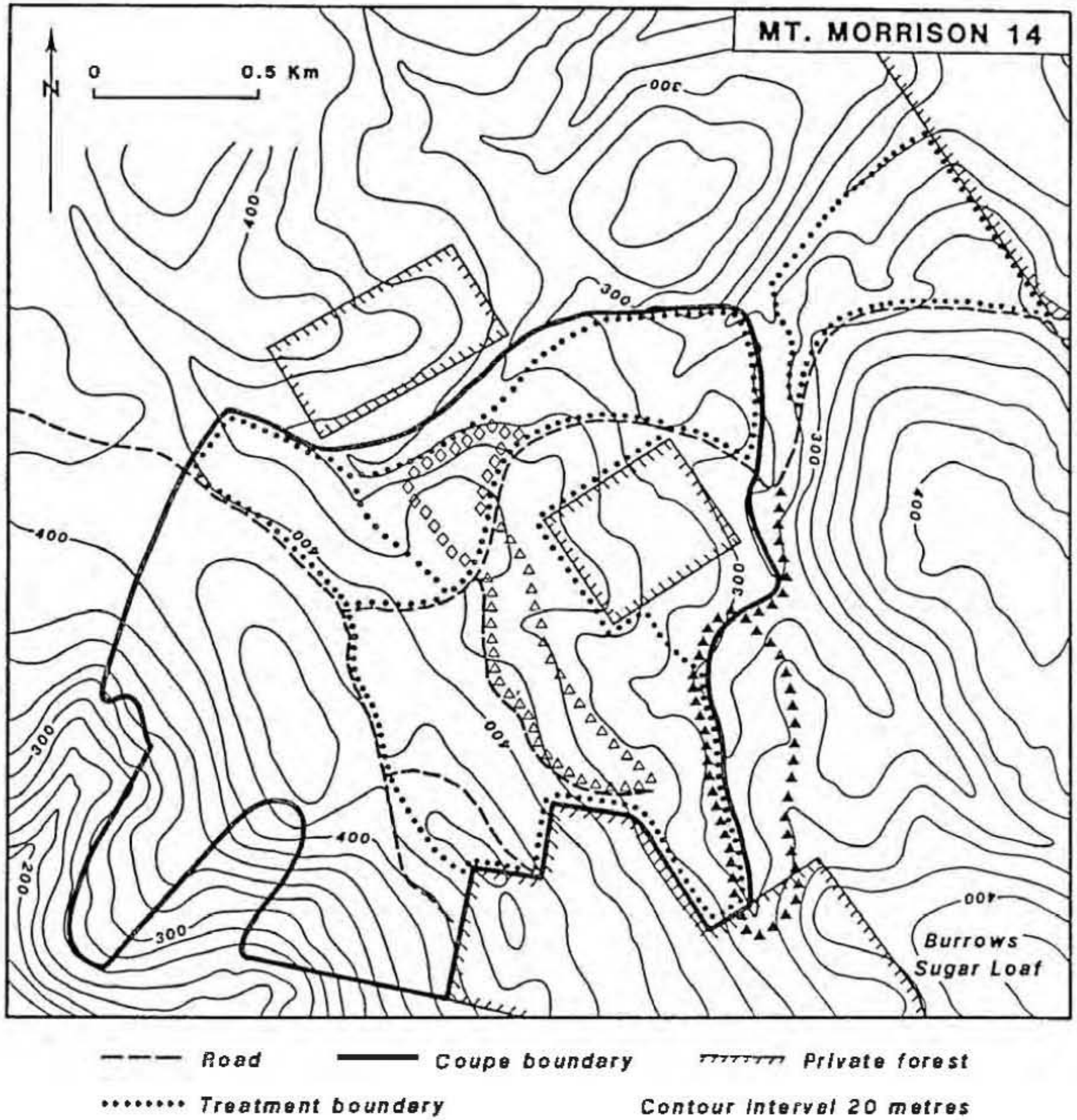
7.2 METHODS

A bird census was conducted at MM14 during 1983 and 1984 at approximately monthly intervals. All surveys were undertaken during the morning between the hours of 08.30 and 12.00, and on each occasion the general weather conditions were noted (Appendix 7).

The bird species were recorded along a 3km transect with the route being chosen so as to cover a diversity of habitats typical of those present in the region of MM14 (Fig. 27). The general habitats included:

(1) Creekside vegetation which consisted of thick undergrowth close to a water course or soak. The plant species were represented by various graminoids, shrubs and small trees, such as *Acacia melanoxylon*, *A. verticillata*, *Gahnia grandis*, *Lepidosperma laterale* and *Leptospermum lanigerum*.

Fig. 27 : The route of the monthly bird census at MM14 through uncut forest (▲), and on treatment B (△) and UB (◇).



(2) Forest dominated by Eucalyptus obliqua but with various other eucalypt species present, including E. globulus and E. viminalis. The understorey consisted oF a combination of graminoids, ferns, small trees and shrubs, for example Acacia dealbata, Epacris impressa, Gahnia grandis, Leptospermum scoparium and Pteridium esculentum.

(3) Forest dominated by Eucalyptus pulchella interspersed with individuals of E. amygdalina, E. globulus and E. viminalis. The understorey consisted generally of a sparse cover of herbs, graminoids, small shrubs and tussock grasses, for example Acacia dealbata, A. stricta, Diplarrena moraea, Helichrysum scorpioides, Lissanthe strigosa and Poa spp..

(4) The margins of uncut forest, dominated by Eucalyptus obliqua, and a clearfelled coupe which had been slash-burnt (MM14: treatment B).

In addition, from March 1984, the census was extended to include sweeps of the central areas of treatment B and treatment UB (Fig. 27).

In all censuses bird species were recorded either as actual sightings or as vocal records only, when the bird was not seen. In the case of sightings, the general habitat in which the bird species occurred was noted, as well as the activity in which the particular individual(s) was(were) engaged. Sightings were registered as single observations even when more than one individual of the species was present. Notes were also made of the plant species associated with each sighting, together with the height class in which the bird species occurred. The latter were based on the structural divisions used in the TASFORHAB classification system (Peters, 1985; see Table 25). In addition, general observations of bird species occurring at MM14 were made during the years 1981 to 1984. Nomenclature of bird species follows Schodde et al. (1977).

7.3 RESULTS

The English and scientific names of the bird species recorded at MM14 during 1981 to 1984 are given in Appendix 8. The 46 species recorded during the monthly censuses, as well as the total number of sightings and general habitat in which they were recorded, are presented in Table 24.

7.3.1 The censuses covering the various habitats in uncut forest

The number of bird species, sightings and vocal records varied with season (Fig. 28) and with weather conditions at the time of, and for the few days preceding the census (Appendix 7). Feeding activity tended to be more pronounced if the census coincided with a period following inclement weather. Activity increased during the breeding season covered by the spring months of September and October, with the maximum number of species (27) being recorded in October 1983. The greatest number of sightings (77) and vocal records (102) were also made on the latter occasion. In comparison, the number of species, sightings and vocal records were low during the winter months of June to August (Fig. 28).

Several species were absent or infrequent at certain times of the year, for example the Striated Pardalote was extremely abundant from September to November in both 1983 and 1984, whilst the Satin Flycatcher was abundant only from November 1983 to February 1984, reappearing in the last census in November 1984. In contrast, the Crescent Honeyeater was most frequent during late autumn and winter.

The most frequently recorded species during the monthly censuses were the Brown Thornbill, Crescent Honeyeater, Superb Fairy-wren and Grey Shrike-thrush. Ten species, which included the Wedge-tailed Eagle, Spotted Quail-thrush and White's Thrush, were recorded on four or less occasions. However, Wedge-tailed Eagles were observed at other times, particularly on clear, calm days, hunting in pairs over the coupe and

TABLE 24: The total number of sightings and the total number of records of bird species recorded at MH14 during the monthly censuses in 1983 and 1984

(A) - the total number of records and sightings, together with the frequency of sightings recorded in the various habitats in uncut forest. Air = species recorded in flight at a height > 41m; Cr = species recorded in creekside vegetation; M = species recorded crossing the margins of uncut forest and clearfelled coupe; O = species recorded in *Eucalyptus obliqua* dominated forest; P = species recorded in *E. pulchella* dominated forest. ( ) = species was very abundant in certain censuses with almost constant calling.

(B) = the total number of records and sightings recorded during the sweeps on treatments B and UB.

(A)			Frequency of sightings					(B)			
			General habitat					Total no. of sightings		Total no. of records	
Species	Total no. of sightings	Total no. of records	Air	Cr	M	O	P	B	UB	B	UB
Wedge-tailed Eagle	1	1	1	-	-	-	-	-	-	-	-
Brown Falcon	4	4	4	-	-	-	-	1	-	1	-
Common Bronzewing	1	2	-	-	-	1	-	-	-	-	-
Brush Bronzewing	1	1	-	-	-	1	-	-	-	-	-
Green Rosella	37	64	1	1	2	21	12	3	1	3	1
Blue-winged Parrot	-	-	-	-	-	-	-	2	-	2	-
Pallid Cuckoo	1	2	-	-	-	-	1	-	-	-	-
Fan-tailed Cuckoo	5	19	-	-	-	5	-	-	-	-	-
Laughing Kookaburra	4	19	-	-	-	4	-	-	1	2	2
Skylark	-	-	-	-	-	-	-	1	-	1	-
Welcome Swallow	2	2	-	-	2	-	-	2	-	2	-
Black-faced Cuckoo-shrike	1	1	-	-	-	1	-	-	-	-	-
White's Thrush	2	2	-	-	-	2	-	-	-	-	-
Flame Robin	9	11	-	-	-	5	4	20	1	20	1
Scarlet Robin	14	17	-	1	2	7	4	1	1	1	1
Dusky Robin	17	20	-	1	6	10	-	10	-	13	-
Golden Whistler	13	26	-	-	1	6	6	-	1	1	1
Grey Shrike-thrush	30	68	-	1	4	21	4	5	-	7	1
Satin Flycatcher	10	(21)	-	1	-	8	1	-	-	-	-
Grey Fantail	54	58	-	17	2	30	5	-	-	-	-
Spotted Quail-thrush	4	4	-	-	-	1	3	-	-	-	-
Superb Fairy-wren	71	76	-	20	19	20	12	31	6	31	8
White-browed Scrub-wren	17	21	-	13	1	3	-	1	-	1	-
Calamanthus	-	-	-	-	-	-	-	1	-	1	-
Brown Thornbill	82	91	-	13	10	41	18	4	7	4	7
Tasmanian Thornbill	34	38	-	16	-	14	4	1	-	1	-
Yellow-rumped Thornbill	-	1	-	-	-	-	-	1	-	1	-
Yellow Wattlebird	2	8	-	-	1	-	1	-	-	-	-
Yellow-throated Honeyeater	19	31	-	-	-	13	6	-	1	-	2
Strong-billed Honeyeater	18	20	-	-	-	18	-	-	-	-	-
Black-headed Honeyeater	36	39	-	-	1	29	6	-	-	-	1
Crescent Honeyeater	51	77	2	1	-	37	11	-	8	-	11
New Holland Honeyeater	1	1	-	-	-	-	1	-	-	-	-
Eastern Spinebill	38	62	-	6	1	25	6	1	12	1	14
Spotted Pardalote	11	20	-	-	1	9	1	1	1	1	1
Striated Pardalote	27	(52)	-	-	-	20	7	4	-	4	3
Silvereye	5	9	-	1	-	4	-	1	-	1	-
Beautiful Firetail	6	6	-	-	5	1	-	2	-	2	-
Dusky Woodswallow	-	1	-	-	-	-	-	1	-	1	-
Grey Butcherbird	1	7	-	-	-	-	1	-	-	-	-
Black Currawong	12	23	5	1	1	5	-	-	1	2	2
Grey Currawong	7	16	1	1	-	4	1	-	2	-	2
Forest Raven	10	21	8	-	-	1	1	1	1	2	1

Additional species (recorded by call only): Yellow-tailed Black-Cockatoo, Shining Bronze-Cuckoo, European Goldfinch.

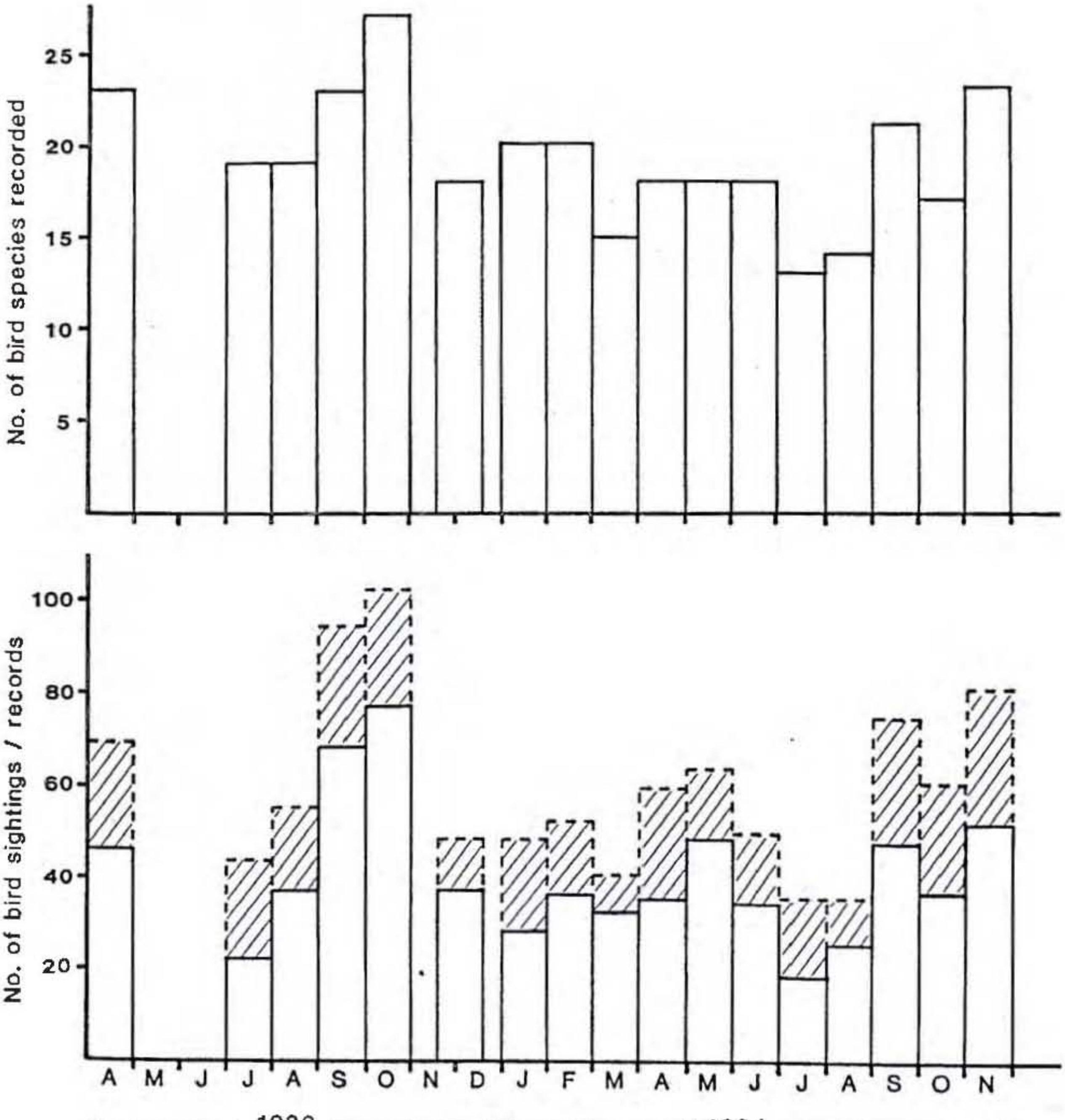


Fig. 28 : The number of bird species recorded at MM14 during each of the monthly censuses in 1983 and 1984, together with the number of sightings and the number of vocal records (shaded) noted on each occasion.

surrounding forest. One pair was disturbed feeding on a freshly killed Bennett's wallaby (Macropus rufogriseus) close to the type P control area in February 1984.

In general, the favoured habitats were those containing creekside vegetation and type O forest, although the situation was complicated by the varying lengths of transect through the different vegetation types. During the course of the censuses, 23 and 31 bird species were recorded in type P and type O communities respectively. The number of sightings and vocal records tended to be greater in type O with certain species commonly occurring together, for example Black-headed Honeyeaters and Strong-billed Honeyeaters often foraged in flocks through the foliage of Eucalyptus obliqua. In the months of May to August it was not uncommon to have large sections of the transect where no sightings or vocal records were made. These gaps in observations would then be interspersed with pulses of bird species activity concentrated in particular areas of mature forest, generally dominated by E. obliqua. This phenomenon was not so evident in the type P habitats which were located on the more exposed, rocky ridges. In addition, on days when there were strong winds bird activity tended to be concentrated in the more sheltered habitats, generally along creeks or on the lower slopes between ridges, rather than on the more exposed sections.

The Tasmanian Thornbill, Brown Thornbill, Superb Fairy-wren, Grey Fantail and White-browed Scrub-wren were the most commonly observed species in creekside vegetation. The Brown Thornbill and Superb Fairy-wren also frequented the areas where uncut forest abutted clearfelled coupe, as well as the Beautiful Firetail which was sighted crossing the forest margins on 5 out of a total of 6 occasions.

The height classes in which bird species were recorded are given in Table 25. The Spotted Quail-thrush, White-browed Scrub-wren and White's Thrush were restricted to the lowest class of 0 to 2m. The Tasmanian Thornbill, Beautiful Firetail, Superb Fairy-wren and Flame Robin were

TABLE 25: The bird species recorded at MM14 during the monthly censuses in 1983 and 1984, together with the height class (m) in which they occurred.

x = recorded in the various habitats in uncut forest (see section 7.3.1); B = recorded during the sweeps on treatment B; UB = recorded during the sweeps on treatment UB. ( ) indicate that the record occurred once only.

Species	Height class (m)																							
	0 - 2			2 - 5			5 - 8			8 - 15			15 - 27			27 - 41			>41			Flying >41		
Wedge-tailed Eagle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-	-
Brown Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	(B)	-
Common Bronzewing	-	-	-	(x)	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-
Brush Bronzewing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Green Rosella	x	B	-	x	-	-	x	-	(UB)	x	B	-	x	-	-	x	-	-	-	-	-	x	-	-
Blue-winged Parrot	-	(B)	-	-	-	-	-	(B)	-	-	-	-	-	(B)	-	-	B	-	-	-	-	-	-	-
Pallid Cuckoo	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-
Fan-tailed Cuckoo	(x)	-	-	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-
Laughing Kookaburra	-	-	-	-	-	-	-	-	-	(x)	-	-	x	-	-	-	-	(UB)	-	-	-	-	-	-
Skylark	-	(B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Welcome Swallow	-	-	-	-	-	-	-	-	-	-	B	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-faced Cuckoo-shrike	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-
White's Thrush	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flame Robin	x	B	(UB)	x	B	-	(x)	(B)	-	x	(B)	-	(x)	B	-	-	-	-	-	-	-	-	-	-
Scarlet Robin	x	(B)	-	x	-	-	x	-	(UB)	x	-	-	x	-	-	(x)	-	-	-	-	-	-	-	-
Dusky Robin	x	B	-	x	B	-	x	-	-	x	B	-	x	-	-	-	-	-	-	-	-	-	-	-
Golden Whistler	x	-	-	x	-	-	-	-	-	(x)	-	(UB)	x	-	-	x	-	-	(x)	-	-	-	-	-
Grey Shrike-thrush	-	-	-	(x)	(B)	-	x	(B)	-	x	(B)	(UB)	x	B	-	x	-	-	x	-	-	-	-	-
Satin Flycatcher	-	-	-	(x)	-	-	-	-	-	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-
Grey Fantail	x	-	-	x	-	-	x	-	-	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-
Spotted Quail-thrush	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Superb Fairy-wren	x	B	UB	x	B	(UB)	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-
White-browed Scrub-wren	x	(B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamanthus	-	(B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Thornbill	x	B	(UB)	x	-	(UB)	x	(B)	-	x	B	UB	x	-	UB	x	-	-	-	-	-	-	-	-
Tasmanian Thornbill	x	(B)	-	x	-	-	x	-	-	x	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-
Yellow-rumped Thornbill	-	-	-	-	-	-	-	(B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Wattlebird	-	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow-throated Honeyeater	-	-	-	(x)	-	-	x	-	(UB)	x	-	-	x	-	-	x	-	-	(x)	-	-	-	-	-
Strong-billed Honeyeater	-	-	-	-	-	-	(x)	-	-	x	-	-	x	-	-	x	-	-	(x)	-	-	-	-	-
Black-headed Honeyeater	-	-	-	(x)	-	-	-	-	-	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-
Crescent Honeyeater	x	-	-	x	-	(UB)	x	-	(UB)	x	-	(UB)	x	-	UB	x	-	-	(x)	-	-	-	-	-
New Holland Honeyeater	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-
Eastern Spinebill	x	(B)	UB	x	-	UB	x	-	UB	x	-	UB	x	-	-	-	-	-	-	-	-	-	-	-
Spotted Pardalote	-	-	-	-	-	-	-	-	-	(x)	-	(UB)	x	-	-	x	-	-	x	-	-	-	-	-
Striated Pardalote	-	(B)	-	(x)	-	-	-	-	-	x	B	-	x	-	-	x	-	-	-	-	-	-	-	-
Silvereye	x	-	-	(x)	-	-	(x)	-	-	-	-	-	-	(B)	-	(x)	-	-	-	-	-	-	-	-
Beautiful Firetail	-	(B)	-	x	(B)	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dusky Woodswallow	-	-	-	-	-	-	-	(B)	-	-	(B)	-	-	-	-	-	-	-	-	-	-	-	-	-
Grey Butcherbird	-	-	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Currawong	-	-	-	(x)	-	-	(x)	(B)	(UB)	x	-	-	x	-	-	(x)	-	(UB)	-	-	-	x	-	-
Grey Currawong	-	-	-	-	-	-	-	-	(UB)	x	-	(UB)	x	-	-	(x)	-	-	(x)	-	-	-	-	-
Forest Raven	-	-	-	-	-	-	-	-	-	-	-	(UB)	-	-	-	(x)	-	-	-	-	-	x	-	-

Additional species (recorded by call only): Yellow-tailed Black-Cockatoo, Shining Bronze-Cuckoo, European Goldfinch.

most commonly sighted in classes up to 15m. The Grey Shrike-thrush, Black Currawong and Grey Currawong were more commonly observed above 8m. The Tasmanian endemics, the Yellow-throated Honeyeater, Black-headed Honeyeater and Strong-billed Honeyeater favoured the height classes from 8 to 41m. The Brown Thornbill, Crescent Honeyeater, Green Rosella and Grey Fantail were recorded feeding in the full range of height classes from 0 to 41m.

During the censuses several nests were observed belonging to the Forest Raven and Black Currawong, as well as two belonging to the Tasmanian endemic Yellow Wattlebird. Individuals of the Green Rosella were seen inspecting a hole in the trunk of an Eucalyptus viminalis tree in April 1983 after the end of the main breeding season, and juveniles were observed in January and February 1984. Spotted Pardalote juveniles were observed in November 1983 feeding in the foliage of Eucalyptus obliqua, whilst evidence of nesting by the Striated Pardalote was recorded in September and October 1983, and November 1984. Juveniles were also observed of the Pallid Cuckoo (January 1984), Fan-tailed Cuckoo (February 1984), Superb Fairy-wren, Strong-billed Honeyeater (February 1984), Black-headed Honeyeater (February 1984), Satin Flycatcher (February 1984) and Grey Fantail (February 1984). A Brown Thornbill was observed carrying nesting material in August 1984.

7.3.2 The censuses covering the sweeps on treatments B and UB

The most commonly observed species on treatment B were the Superb Fairy-wren, Flame Robin and Dusky Robin (Table 24). All were commonly seen feeding from 0 to 2m or perched on dead trees or stumps (Table 25). The Skylark, Blue-winged Parrot and Calamanthus were recorded only on treatment B (Table 24). Small flocks of the Blue-winged Parrot, numbering up to 14 individuals, were observed consistently on treatment B either feeding on the ground or perched on dead trees from November to March in the years 1982/83 and 1983/84.

On treatment UB the most commonly observed species was the Eastern Spinebill which frequented the structural classes from 0 to 15m, feeding preferentially in the understorey vegetation from 0 to 5m. The Superb Fairy-wren did not favour treatment UB to the same extent as treatment B, even allowing for the differences in length of the individual sweeps. The majority of the other species recorded on both treatments were seen perched or feeding in the foliage of the few standing trees (culls) which had retained their canopy following forest utilisation.

7.4 DISCUSSION

The seasonal and day to day variation in avian behaviour observed in this study has been noted elsewhere (e.g. Driscoll, 1977; Ratkowsky and Ratkowsky, 1977; Pattemore, 1980; Thomas, 1980). Various species which were absent for much of the year from MM14 are summer migrants which come to Tasmania from the Australian mainland, for example the Satin Flycatcher, Welcome Swallow and Blue-winged Parrot (Pattemore, 1980). The honeyeater species are nomadic with a tendency to move to low altitudes in winter (Thomas, 1980). During the censuses at MM14 the Eastern Spinebill was particularly abundant when the heath species Epacris impressa was in flower, which generally occurred in late winter and early spring. In addition, the Crescent Honeyeater was noticeably more numerous in late autumn and winter (section 7.3.1). The increased activity of the Striated Pardalote at certain times of the year has also been observed within dry forests by Pattemore (1980), who noted a greater abundance of the species during the breeding season from November to February compared to other months.

The influence of weather conditions on bird numbers which was observed during the present study has also been described by Ratkowsky and Ratkowsky (1979) during surveys on Mt. Wellington, near Hobart.

Heavy rain or windy conditions may depress bird activity by reducing the availability of insects for forage (Franzreb, 1977).

Dry sclerophyll forest in Tasmania supports 59 species out of a total of 70 regular forest avifauna (Thomas, 1979). The total number of species in any one locality depends on the structural complexity, foliage density, and maturity of the forest (MacArthur and MacArthur, 1961; MacArthur, 1964; Recher, 1971; Loyn et al., 1980; Friend, 1982). Moreover, bird populations tend to be higher in gullies than on ridges (cf. Loyn, 1980). Where one habitat abuts with another, as in the case of the margins of uncut forest and the clearfelled coupe, a number of species can make use of both environments (cf. Friend, 1982).

Similar foraging habitats to those used by the avifauna observed at MM14 have been described by Pattemore (1980) and Wilson (1981) both of whom wrote on the effect of forest utilisation on dry forest birds. Both authors describe mature forest as supporting the highest number of avian species whereas in contrast, areas which had been clearfelled supported low bird species numbers for the first few years following utilisation. The results from the sweeps on treatments B and UB at MM14 indicate that bird species which can exploit open ground habitats, such as the Superb Fairy-wren and Blue-winged Parrot, favour a slash-burnt environment over an equivalent unburnt site for at least 2 years after burning. However, unburnt slash can provide important foraging sites in their own right, as made evident by Conner and Adkisson (1975) for some North American species, and by Loyn et al. (1980) for birds in Victoria.

Nevertheless, not all species which utilise the lowest vegetation stratum of 0 to 2m are unaffected by clearfelling. For example, White's Thrush, a species common in wet forest habitats (Blakers et al., 1984) but not usually associated with dry communities, was only recorded in undergrowth within the type 0 forest. In addition, some concern has been expressed over the status of the Spotted Quail-thrush in areas of clearfelled forest. The Spotted Quail-thrush was not recorded outside uncut forest at MM14, however Pattemore (1980) observed the species in regrowth forest on a sandstone site which had not been slash-burnt, which led Wilson (1981) to speculate that the species may be able to withstand logging activity if the forest is allowed to regenerate without fire.

The importance of cull trees within clearfelled areas as foraging sites and perches for certain bird species has also been documented by Loyn et al. (1980), who noted that the Dusky Woodswallow and Flame Robin required cull trees for both perches and nest sites. Dead standing trees within forest habitats have a multipurpose role in the life cycle of many fauna (McClelland and Frissell, 1975) making it important to identify, and retain, cull trees in any forest management practice. The nesting requirements of many Australian landbirds have been emphasised by Disney and Stokes (1976), who stated that in dry sclerophyll forest holes of suitable size for nesting may take in excess of 100 years to develop. Thus, from a wildlife viewpoint the retention of cull trees of varying ages following clearfelling is more likely to provide a supply of suitable breeding sites within the regenerating forest, until such time that the regrowth eucalypts have formed their own holes. It can be seen that within a forest industry managed on rotation cycles of less than 80 years, there is little chance that trees will have developed holes of suitable size and number to support the full range of dry forest fauna. Of the avian species, examples of those most likely to be adversely affected are the Australian endemics, the Yellow-tailed Black-Cockatoo and Swift Parrot, the Tasmanian endemic Green Rosella, and the owl species, the Southern Boobook and the Masked Owl, all of which feed and nest in mature trees (Pattemore, 1980; Wilson, 1981). The formation of holes within eucalypts and their importance for particular fauna is currently under investigation (D. Peters, personal communication).

Prescribed burning undertaken beneath the regenerating forest during the course of a particular rotation cycle (see section 6.5) may be disadvantageous to some species, especially those which depend on ground habitats (e.g. Spotted Quail-thrush). The management strategy involving fires of varying intensity, patchy distribution and differing fire-free interval that was proposed in Chapter 6 on the basis of the results presented in Chapters 2 to 5, has also been advocated by authors who have concentrated on wildlife studies in fire-prone forests (e.g. Cowley, 1971; Christensen and Kimber, 1975; Loyn, 1980; Fox and McKay, 1981). In addition, a mosaic of mature forest covering habitats spanning ridges and gullies and linking different drainage areas, as well as regenerating stands of varying ages, is seen as a minimum requirement for wildlife management within any dry forest used by industry (Loyn et al., 1980; Pattemore, 1980; Recher et al., 1981; Statham, 1984).

CHAPTER 8

GENERAL CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

8.1 A SUMMARY OF FINDINGS

1. Does the combined disturbance of clearfelling and slash-burning have a greater ecological impact than clearfelling alone, and if so what is the nature of this impact?

The present study has shown that clearfelling plus slash-burning does result in a greater ecological shift than either clearfelling alone or no intervention.

In the short-term, at least, the disturbance of clearfelling allows the invasion of some alien species. However, after clearfelling without burning there is no marked shift in species composition or relative abundance in the understorey.

After clearfelling and slash-burning plant cover is temporarily absent. After regrowth commences the occurrences and relative abundances of dry forest plant species vary greatly according to environmental situation, fire intensity and their regenerative properties. However, the plant communities are highly resilient. The pre-disturbance dominants survive. There is an increase in quadrat species richness for at least 2 years after the disturbance. Directly following fire there is a flush in species recruitment. As numbers of individuals become more numerous increasing mortality occurs. Mortality is greatest in areas of herb and grass cover.

2. Do the dry forests on dolerite in southeastern Tasmania conform to models of secondary succession following fire?

Very few species are short-lived post-burn colonisers. The pre-disturbance species are essentially present on the site within 2 years of burning. Consequently, succession in clearfelled dry forests does not conform to the relay floristic model. Nevertheless, the initial floristic composition model is an inadequate descriptor as quadrat species richness increases following slash-burning.

The succession of species after clearfelling and slash-burning appears idiosyncratic. Variations in local environments, fire intensity, seed availability and the capacity for vegetative propagation all influence the species composition of particular sites.

3. Does the combination of clearfelling and slash-burning encourage grazing and browsing?

Slash-burning does encourage grazing and browsing compared to levels of predation recorded in unburnt clearfelled and uncut dry forests. However, the impact varies between forest types. Type O forest appears to sustain a greater degree of post-fire predation than type P forest.

In general, herbs, grasses, graminoids and leguminous shrubs are grazed preferentially. Following fire, grazing maintains plants in the early stages of their life cycle. Exclosure allows certain heavily grazed species to change from a palatable to a non-palatable phenology. Other species thrive despite grazing pressure and some appear stimulated by predation.

Grazing and browsing affects the relative abundance of plant species, with unpalatable vegetative reproducers often achieving early post-fire dominance. However, overall, predation does not appear to alter floristic composition except in localised areas. Protection from grazing can lead to some species being outcompeted, and thus to their disappearance.

4. How does slash-burning affect fuel structure, fuel composition and fuel arrangements over time?

Slash-burning significantly reduces the fine fuel load consisting of material <1.5 cm in diameter or thickness. However, there is no statistically significant reduction in coarse fuel >2.0 cm in diameter or thickness, or in fine fuel 1.5 - 2.0 cm in diameter or thickness, following burning.

After slash-burning the accumulation of fine fuel compacted at ground level does not attain levels equivalent to those present on unburnt treatments for at least 9 years after fire in types P and O, and after 8 years in type D/O. However, ground fuel levels in unburnt clearfelled treatments appear to have stabilised.

In types P and O, elevated dead material on burnt treatments stabilises at levels similar to those on unburnt treatments within 2 years of burning. Similarly, live vegetation, both elevated and at ground level, recovers rapidly following fire, and may in certain instances exceed levels on equivalent unburnt sites. Decorticating gum bark and dead herbaceous vegetation appear favoured by burning. Levels of the latter were greater 5 years after slash-burning than on clearfelled sites 2 years after logging with slash left unburnt.

The vertical structure of live and dead fuels on burnt sites becomes more evenly distributed with increasing age of regeneration. The above-ground vertical live fuel structure on burnt treatments rapidly approaches the structure present on unburnt treatments.

5. Does burning increase the flammability of the forest by encouraging the dominance and persistence of fire-dependent plant species?

General support is given to the hypothesis that natural selection has favoured flammable characteristics in fire-dependent plant communities with species from the least-burned localities showing the least tendency to propagate fire. Of the plant species tested, eucalypt dry forest species have the highest energy content and the greatest tendency to propagate fire, whereas species from wet forest and *Casuarina* dry forest communities propagate fire less readily. Species from dry habitats have, in general, low ash contents, high energy levels, high volatile oil contents and low moisture contents. Wet habitat species have high percentages of moisture and ash.

6. *For how long does slash-burning effectively reduce fire hazard on a site?*

In general, enough fuel of sufficient continuity is present in 3 to 5 year-old regeneration to carry a fire which would be difficult to control in conditions of severe fire danger. Regrowth in type O communities is likely to present a greater fire hazard than that in type P, with fuel loads tending to be greater and more continuous in the former.

7. *Does slash-burning result in enhanced growth of the regenerating stand compared to equivalent unburnt sites?*

There was little evidence to suggest that eucalypt productivity on slash-burnt sites was greater than on equivalent unburnt sites. The majority of regrowth on the slash-burnt areas was from sources other than seed. Following clearfelling, it is possible that eucalypt regrowth present on type O sites may have an 8 to 9 year overall advantage compared to regrowth on equivalent burnt sites. However, the size of this advantage will vary from site to site and between vegetation types.

8. What implications did the differences in fire hazard on burnt and unburnt sites have for eucalypt productivity over the complete rotation cycle?

The percentage loss in productivity compared to the total productivity possible, that is sustained by an unburnt clearfelled treatment compared with a slash-burnt site varies according to length of rotation cycle, fire probability and fire protection period. In turn, the fire protection period on a slash-burnt site varies spatially depending on environmental and plant community characteristics. Burning favours species which have the capacity to regenerate by vegetative means, and often these species are highly flammable.

The percentage loss in productivity of an unburnt stand compared to an equivalent slash-burnt site decreases in a curvilinear fashion with increasing length of rotation cycle. The loss is likely to be less than 1% of the total productivity possible over rotation cycles of 60 to 80 years with realistic levels of wildfire probability.

9. Can slash-burning be justified in productivity terms considering the loss of advanced growth on unburnt sites?

If the advanced growth on unburnt sites has a greater than 3 year age advantage over equivalent burnt treatments it is dubious whether slash-burning will induce a justifiable productivity gain in the eucalypt crop from one harvest to the next. If a clearfelled treatment has very poor advanced growth then fire is probably the best way of reducing competition to provide the chance for successful eucalypt establishment, provided that sowing of seed occurs soon after burning.

10. <u>Does the combined disturbance of clearfelling and slash-burning restrict bird species composition and abundance to a greater degree than clearfelling alone?</u>

The avifauna of recently clearfelled areas is severely restricted compared to the composition and abundance in uncut mature forest. However, some bird species which can exploit open ground habitats favour a slash-burnt environment over an equivalent unburnt site for at least 2 years after burning. Nevertheless, unburnt slash can provide important foraging sites in its own right for certain species.

Bird species richness and abundance on clearfelled areas is greatly increased by the availability of cull trees which retain their foliage after the logging operation. Culls may be used as forage, perch or nest sites.

8.2 IMPLICATIONS FOR MANAGEMENT

Most dry forest plant species are adapted to burning but have highly variable responses to differences in fire intensity and fire frequency. The dry forest plant species are certainly not pre-adapted to the massive physical upheaval which would result from programmes of mechanical disturbance involving the use of machinery.

With regard to fire hazard slash-burning does significantly reduce fine fuel loads immediately following fire but is ineffective in significantly reducing coarse fuels. In most cases the short-term protection from wildfire which is gained in a slash-burnt area is not justifiable in terms of eucalypt productivity over complete rotation cycles. Slash-burning results in substantial loss of the advanced growth present on unburnt clearfelled areas. Where necessary, regeneration on unburnt sites may be supplemented by artificial sowing of seed.

There seems no reason to suggest a policy of total fire exclusion nor a policy involving widespread hot fires. A system of hazard reduction burns involving fires of variable intensity and patchy distribution, and of differing fire-free interval is likely to maintain floristic variation and to maximise the number of clearfelled habitats available to wildlife. However, too frequent burning will tend to favour those plant species best adapted to regenerate and compete in that particular fire regime and could increase rather than decrease, forest fire hazard.

8.3 SUGGESTIONS FOR FUTURE WORK

The work reported in this thesis does not provide conclusive answers to many important questions concerning the impact of clearfelling and burning on the dry forest environments. The following important aspects need further study:

1. The experiment at MM14 was not designed in such a way that studies could be conducted into the effects of clearfelling and slash-burning on rare plants. No conclusions could be drawn as to whether the current forestry management practices could lead to the extinction of particular species that are presently unreserved and rare.

2. This thesis reports research into the short-term effects of clearfelling and slash-burning on vegetation dynamics. The long-term effects on secondary succession, species richness, species demography, persistence of exotics and relative abundance of species remain uninvestigated. The experimental work described and studied in this thesis is to be continued on a long-term basis (J.B. Kirkpatrick, personal communication).

3. Grazing and browsing after burning in clearfelled forest may be greater than predation after fire in uncut forest. There are no data in this thesis which could be used to examine this possibility. If slash-burning results in an increased intensity of grazing and browsing compared to post-fire predation in uncut forest the relative abundances of understorey species may be affected.

4. This thesis could not report on the effects of grazing and browsing on tree species. Eucalypts may be predated to such an extent that regeneration is restricted. Alternatively, the reduced competition resulting from intense grazing of other species such as grasses and herbs may result in increased growth of the eucalypt crop. Thus, predation by native fauna may turn out to indirectly stimulate eucalypt growth in clearfelled dry forests.

5. The relative success of artificially sown seed from alien provenance sources compared to indigenous source material remains unstudied. Likewise, the effects of aerial sowing of seed with little allowance for local topographic variation need attention.

6. This study indicated that some native plant species were suffering considerable dieback. However, no conclusions could be drawn as to whether the cause of death was a fungal pathogen or natural senescence. Research into the fungal pathogens associated with native species other than those having commercial value is needed.

7. This study reported the use made by bird species of cull trees in both burnt and unburnt clearfelled areas. Research is needed into the optimal density and spacing of cull trees in order to maximise the forage, nest and perch sites available to wildlife in clearfelled areas.

8. More research is needed of the faunal groups which have lacked attention in wildlife studies concerned with forestry practices, for example mammals, invertebrates, reptiles and amphibians.

9. Modelling of fire spread within Australian slashed environments has received scant attention and requires further study.

10. Is clearfelling the appropriate method for dry forest utilisation? The answer to this question requires an experimental design involving selectively logged areas and a critical dissection of the short and long-term economics of the various silvicultural systems.

REFERENCES

ABBOTT, I. & LONERAGAN, O. (1984) Growth rate and long-term population dynamics of jarrah (Eucalyptus marginata Donn ex Sm.) regeneration in Western Australian forest. Australian Journal of Botany 32, 353-362.

ANDERSON, H.E. (1969) Heat transfer and fire spread. United States Department of Agriculture, Forest Service Research Paper INT-69.

ANDERSON, H.E. (1970) Forest fuel ignitibility. Fire Technology 6, 312-319.

ARTLEY, D.K., SHEARER, R.C. & STEELE, R.W. (1978) Effects of burning moist fuels on seedbed preparation in cutover western larch forests. United States Department of Agriculture, Forest Service Research Paper INT-211.

ASSMANN, E. (1970) The Principles of Forest Yield Study. Pergamon Press, Oxford.

ATTIWILL, P.M. (1968) The loss of elements from decomposing litter. Ecology 49, 142-145

AUSTIN, M.P. (1981) Permanent quadrats: an interface for theory and practice. Vegetatio 46, 1-10.

BAKER, R.T. & SMITH, H.G. (1902) A Research on the Eucalypts, Especially in Regard to Their Essential Oils. Government Printer, New South Wales, Technical Education Series No. 13, Sydney.

BEADLE, N.C.W. (1940) Soil temperatures during forest fires and their effect on vegetation survival. Journal of Ecology 28, 180-192.

BELL, D.T. & KOCH, J.M. (1980) Post-fire succession in the northern jarrah forest of Western Australia. Australian Journal of Ecology 5, 9-14.

BLAKERS, M., DAVIES, S.J.J.F. & REILLY, P.N. (1984) The Atlas of Australian Birds. Melbourne University Press, Melbourne.

BOWMAN, D.M.J.S. (1981a) The use of Tasmanian forests. Wilderness, Journal of the Tasmanian Wilderness Society No. 17, 8-11.

BOWMAN, D.M.J.S. (1981b) Slash burning: some short term considerations. Search 12, 250-251.

BOWMAN, D.M.J.S. (1984) The ecology and silviculture of Eucalyptus delegatensis R.T. Baker, on dolerite in Tasmania. Ph.D. thesis, University of Tasmania.

BOWMAN, D.M.J.S. & JACKSON, W.D. (1981) Slash-burning in the regeneration of dry eucalypt forests. Australian Forestry 44, 118-124.

BOWMAN, D.M.J.S. & KIRKPATRICK, J.B. (1984) Geographic variation in the demographic structure of stands of *Eucalyptus delegatensis* R.T. Baker, on dolerite in Tasmania. Journal of Biogeography 11, 427-437.

BRIDGEWATER, P.B. & BACKSHALL, D.J. (1981) Dynamics of some Western Australian ligneous formations with special reference to the invasion of exotic species. Vegetatio 46, 141-148.

BRITTON, C.M., DODD, J.D. & WEICHERT, A.T. (1976) Energy values of plant species and litter of an *Andropogon-Paspalum* grassland. Journal of Biogeography 3, 389-395.

BROIDO, A. & NELSON, M. (1964) Ash content - its effect on combustion of corn plants. Science 146, 652-653.

BROWN, A.A. & DAVIS, K.P. (1973) Forest Fire : Control and Use, 2nd edn. McGraw-Hill, New York.

BROWN, J.K. (1970a) Ratios of surface area to volume of common fine fuels. Forest Science 16, 101-105.

BROWN, J.K. (1970b) Vertical distribution of spruce-fir logging slash. United States Department of Agriculture, Forest Service Research Paper INT-81.

BROWN, J.K. (1971) A planar intersect method for sampling fuel volume and surface area. Forest Science 17, 96-102.

BROWN, J.K. (1972) Field test of a rate-of-fire-spread model in slash fuels. United States Department of Agriculture, Forest Service Research Paper INT-116.

BROWN, M.J. & BAYLEY-STARK, H.J. (1979) Vegetation of Maria Island. National Parks and Wildlife Service, Tasmania, Wildlife Division Technical Report 79/1.

BROWN, M.J. & PODGER, F.D. (1982) Floristics and fire regimes of a vegetation sequence from sedgeland-heath to rainforest at Bathurst Harbour, Tasmania. Australian Journal of Botany 30, 659-676.

BRYANT, W.G. (1971) Grazing, burning and regeneration of tree seedlings in *Eucalyptus pauciflora* woodlands. Journal of the Soil Conservation Service of New South Wales 27, 121-134.

BRYANT, W.G. (1973) The effects of grazing and burning on a mountain grassland, Snowy Mountains, New South Wales. Journal of the Soil Conservation Service of New South Wales 29, 29-42.

BUREAU OF METEOROLOGY (1978) The Climate of Hobart, Tasmania: Capital City Series. Bureau of Meteorology, Department of Science, Canberra.

BYRAM, G.M. (1959) Combustion of forest fuels. In: Forest Fire : Control and Use (ed. K.P. Davis), pp. 61-89. McGraw-Hill, New York.

CARNE, P.B., GREAVES, R.T.G. & McINNES, R.S. (1974) Insect damage to plantation grown eucalypts in north coastal New South Wales, with particular reference to Christmas beetles (Coleoptera : Scarabaeidae). Journal of the Australian Entomological Society 13, 189-206.

CARR, S.G.M. & TURNER, J.S. (1959) The ecology of the Bogong High Plains. II. Fencing experiments in grassland C. Australian Journal of Botany 1, 34-63.

CARRODUS, B.B. & BLAKE, T.J. (1970) Studies on the lignotubers of *Eucalyptus obliqua* L'Hérit. I. The nature of the lignotuber. New Phytologist 69, 1069-1072.

CASPERS, N. (1977) Seasonal variations in caloric values in herbaceous plants. Oecologia (Berlin) 26, 379-383.

CHAMBERS, D.M. & BRETTINGHAM-MOORE, C.G. (1967) Report and summary of evidence of the bush fire disaster of 7th February, 1967. Parliament of Tasmania, Hobart, Parliamentary Paper No. 16.

CHENEY, N.P. (1981) Fire behaviour. In: Fire and the Australian Biota (eds. A.M. Gill, R.H. Groves & I.R. Noble), pp. 151-175. Australian Academy of Science, Canberra.

CHILDS, T.W. (1939) Decay of slash on clear-cut areas in the Douglas fir region. Journal of Forestry 37, 955-959.

CHRISTENSEN, P.E. & KIMBER, P.C. (1975) Effect of prescribed burning on the flora and fauna of south-west Australian forests. Proceedings of the Ecological Society of Australia 9, 85-106.

CONNELL, J.H. & SLATYER, R.O. (1977) Mechanics of succession in natural communities and their role in community stability and organisation. American Naturalist 111, 1119-1144.

CONNER, R.N. & ADKISSON, C.S. (1975) Effects of clearcutting on the diversity of breeding birds. Journal of Forestry 73, 781-785.

COUNTRYMAN, C.M. & PHILPOT, C.W. (1970) Physical characteristics of chamise as a wildland fuel. United States Department of Agriculture, Forest Service Research Paper PSW-66.

COWLEY, R.D. (1971) Birds and forest management. Australian Forestry 35, 234-250.

COWLEY, R.D., HEISLERS, A. & EALEY, E.H.M. (1969) Effects of fire on wildlife. Victoria's Resources 11, 18-22.

CREMER, K.W. (1960) Problems of eucalypt regeneration in the Florentine Valley. Appita 14, 71-78.

CREMER, K.W. (1969) Browsing of mountain ash regeneration by wallabies and possums in Tasmania. Australian Forestry 33, 201-209.

CREMER, K.W. & MOUNT, A.B. (1965) Early stages of plant succession following the complete felling and burning of *Eucalyptus regnans* forest in the Florentine Valley, Tasmania. Australian Journal of Botany 13, 303-322.

CUNNINGHAM, T.M. (1960) The natural regeneration of *Eucalyptus regnans*. School of Forestry, University of Melbourne, Bulletin No. 1.

CURTIS, W.M. (1963) The Student's Flora of Tasmania, Vol. II. Government Printer, Tasmania.

CURTIS, W.M. (1967) The Student's Flora of Tasmania, Vol. III. Government Printer, Tasmania.

CURTIS, W.M. (1979) The Student's Flora of Tasmania, Vol. IV. Government Printer, Tasmania.

CURTIS, W.M. & MORRIS, D.I. (1975) The Student's Flora of Tasmania, Vol. I, 2nd edn. Government Printer, Tasmania.

CURTIS, W.M. & STONES, M. (1978) The Endemic Flora of Tasmania, Vol. VI. Ariel Press, London.

DAUBENMIRE, R. (1968) Ecology of fire in grasslands. Advances in Ecological Research 5, 209-266.

DeBENEDETTI, S.H. & PARSONS, D.J. (1984) Postfire succession in a Sierran subalpine meadow. American Midland Naturalist 111, 118-125.

DISNEY, H.J. de S. & STOKES, A. (1976) Birds in pine and native forests. Emu 76, 133-138.

DREW, W.B. (1947) Floristic composition of grazed and ungrazed prairie vegetation in north-central Missouri. Ecology 28, 26-41.

DRISCOLL, P.V. (1977) Comparison of bird counts from pine forests and indigenous vegetation. Australian Wildlife Research 4, 281-288.

DUNCAN, F. (1981a) Regeneration and species diversity in a Tasmanian dry sclerophyll forest. In: Fire and Forest Management in Tasmania (ed. J. B. Kirkpatrick), pp. 33-44. Tasmanian Conservation Trust, Hobart.

DUNCAN, F. (1981b) Dry sclerophyll communities. In: The Vegetation of Tasmania (ed. W.D. Jackson), pp. 61-67. Australian Academy of Science, Canberra.

DYRNESS, C.T. (1973) Early stages of plant succession following logging and burning in the Western Cascades of Oregon. Ecology 54, 57-69.

EGLER, F.E, (1954) Vegetation science concepts. I. Initial floristic composition - a factor in old field vegetation development. Vegetatio 4, 412-417.

ELLISON, L. (1960) Influence of grazing on plant succession in rangelands. Botanical Review 26, 2-78.

EVANS, B.T. (1978) Regeneration of native forests in Tasmania, operational procedures. Charles Henry Barbour Forestry Foundation Travel Award, 1977, Forests Commission, Victoria.

FAHNESTOCK, G.R. (1960) Logging slash flammability. United States Department of Agriculture, Forest Service Research Paper No. 58.

FAHNESTOCK, G.R. (1970) Two keys for appraising forest fire fuels. United States Department of Agriculture, Forest Service Research Paper PNW-99.

FAHNESTOCK, G.R. & DIETERICH, J.R. (1962) Logging slash flammability after five years. United States Department of Agriculture, Forest Service Research Paper No. 70.

FELTON, K.C. (1976) Regeneration of cut-over areas of Tasmanian eucalypt forests. In: Woodchip Symposium Papers, 47th ANZAAS Congress, Hobart, May 1976, pp. 1-22. Forestry Commission, Tasmania.

FELTON, K.C. (1982) Slash-burning in Tasmanian dry eucalypt forests. Comment. Search 45, 62-63.

FELTON, K.C. & CUNNINGHAM, T.M. (1971) Woodchip exports and pulpwood forestry in eastern Tasmania. Paper presented to the 6th Conference of the Institute of Foresters of Australia, Thredbo.

FLOYD, A.G. (1966) Effect of fire on weed seeds in wet sclerophyll forests of northern New South Wales. Australian Journal of Botany 14, 243-256.

FLOYD, R.B. (1980) Density of Wallabia bicolor (Desmarest) (Marsupialia : Macropodidae) in eucalypt plantations of different ages. Australian Wildlife Research 7, 333-337.

FONS, W.L. (1946) Analysis of fire spread in light forest fuels. Journal of Agricultural Research 72, 93-121.

FOX, B.J. & McKAY, G.M. (1981) Small mammal responses to pyric successional changes in eucalypt forest. Australian Journal of Ecology 6, 29-41.

FOX, L.R. & MORROW, P.A. (1983) Estimates of damage by herbivorous insects on Eucalyptus trees. Australian Journal of Ecology 8, 139-147.

FRANDSEN, W.H. (1973) Effective heating of fuel ahead of a spreading fire. United States Department of Agriculture, Forest Service Research Paper INT-140.

FRANDSEN, W.H. & ANDREWS, P.L. (1979) Fire behavior in nonuniform fuels. United States Department of Agriculture, Forest Service Research Paper INT-232.

FRANDSEN, W.H. & SCHUETTE, R.D. (1978) Fuel burning rates of downward versus horizontally spreading fires. United States Department of Agriculture, Forest Service Research Paper INT-214.

FRANKCOMBE, D.W. (1966) The regeneration burn. Appita 19, 127-132.

FRANZREB, K.E. (1977) Bird population changes after timber harvesting of a mixed conifer forest in Arizona. United States Department of Agriculture, Forest Service Research Paper RM-184.

FRIEND, G.R. (1982) Bird populations in exotic pine plantations and indigenous eucalypt forests in Gippsland, Victoria. Emu 82, 80-89.

FUJIOKA, F.M. (1976) Fine fuel moisture measured and estimated in dead Andropogon virginicus in Hawaii. United States Department of Agriculture, Forest Service Research Note PSW-317.

GARDNER, C.A. (1957) The fire factor in relation to the vegetation in Western Australia. Western Australian Naturalist 5, 166-173.

GENTILLI, J. (1972) Australian Climate Patterns. Nelson, Adelaide.

GILBERT, J.M. (1958) Eucalypt-rainforest relationships and the regeneration of the eucalypts. Ph.D. thesis, University of Tasmania.

GILBERT, J.M. (1959) Forest succession in the Florentine Valley, Tasmania. Papers and Proceedings of the Royal Society of Tasmania 93, 129-152.

GILBERT, J.M. (1960) Regeneration of Eucalyptus regnans in the Florentine Valley. Appita 13, 132-135.

GILBERT, J.M. (1961) The effects of browsing by native animals on the establishment of seedlings of Eucalyptus regnans in the Florentine Valley, Tasmania. Australian Forestry 25, 116-121.

GILBERT, J.M. & CUNNINGHAM, T.M. (1972) Regeneration of harvested forests. Appita 26, 43-46.

GILL, A.M. (1975) Fire and the Australian flora: a review. Australian Forestry 38, 4-25.

GILL, A.M. (1977) Management of fire-prone vegetation for plant species conservation in Australia. Search 8, 20-26.

GILL, A.M. (1978) The role of species characteristics of plants in fire climates as a guide to management. In: Fire and fuel management problems in mediterranean-climate ecosystems: research priorities and programmes. U.N.E.S.C.O. 1978, MAB Technical Notes 11, 11-16.

GILL, A.M. (1981) Coping with fire. In: The Biology of Australian Plants (ed. J.S. Pate & A.J. McComb), pp. 65-87. University of Western Australia Press, Nedlands, Western Australia.

GILL, A.M. & ASHTON, D.H. (1968) The role of bark type in relative tolerance to fire in three central Victorian eucalypts. Australian Journal of Botany 16, 491-498.

GILL, A.M., GROVES, R.H. & NOBLE, I.R. (eds.) (1981) Fire and the Australian Biota. Australian Academy of Science, Canberra.

GILL, A.M., TROLLOPE, W.S.W. & MacARTHUR, D.A. (1978) Role of moisture in the flammability of natural fuels in the laboratory. Australian Forest Research 8, 199-208.

GIMINGHAM, C.H., HOBBS, R.J. & MALLIK, A.U. (1981) Community dynamics in relation to management of heathland vegetation in Scotland. Vegetatio 46, 149-155.

GOLLEY, F.B. (1969) Caloric value of wet tropical forest vegetation. Ecology 50, 517-519.

GREAVES, R.T.G. (1966) Insect defoliation of eucalypt regrowth in the Florentine Valley, Tasmania. Appita 19, 119-126.

GREEN, R.H. (1980) Birds in initial eucalypt regeneration. Paper presented to the 78th Annual Congress of the Royal Australasian Ornithologists Union, Hobart, December 1980.

GRIME, J.P. (1979) Plant Strategies and Vegetation Processes. Wiley & Sons, Chichester.

GUILER, E.R. (1965) Animals. In: The Atlas of Tasmania (ed. J.L. Davies), pp. 36-37. Government Printer, Hobart.

HANES, T.L. (1971) Succession after fire in the chaparral of southern California. Ecological Monographs 41, 27-52.

HARPER, J.L. (1977) Population Biology of Plants. Academic Press, London.

HARPER, J.L., CLATWORTHY, J.N., McNAUGHTON, I.H. & SAGAR, G.R. (1961) The evolution and ecology of closely related species living in the same area. Evolution 15, 209-227.

HARRIS, S. & KIRKPATRICK, J.B. (1982) The vegetation of Schouten Island, Tasmania. Papers and Proceedings of the Royal Society of Tasmania 116, 117-141.

HARWOOD, C.E. & JACKSON, W.D. (1975) Atmospheric losses of four plant nutrients during a forest fire. Australian Forestry 38, 92-99.

HATCH, A.B. (1969) The estimation of fire hazard in Western Australia. Forests Department, Western Australia, Bulletin No. 77.

HAUKIOJA, E. (1980) On the role of plant defences in the fluctuation of herbivore populations. Oikos 35, 202-213.

HEIM, G. (1974) L'utilité du concept de valeur énergétique en écologie: une étude basée sur des mesures effectuées sur des plantes méditerranéenes. Oecologia Plantarum 9, 281-286.

HILL, G.J.E. (1978) Preliminary assessment of defaecation patterns for the Eastern Grey Kangaroo (Macropus giganteus). Australian Zoologist 19, 291-300.

HILL, M.O. (1973) Diversity and evenness: a unifying notation and its consequences. Ecology 54, 427-432.

HILL, M.O. (1979a) TWINSPAN - a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York.

HILL, M.O. (1979b) DECORANA - a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Section of Ecology and Systematics, Cornell University, Ithaca, New York.

HILL, M.O. & GAUCH, H.G.Jr. (1980) Detrended correspondence analysis: an improved ordination technique. Vegetatio 42, 47-58.

HOBBS, R.J. & GIMINGHAM, C.H. (1980) Some effects of fire and grazing on heath vegetation. Bulletin of Ecology 11, 709-715.

HOGG, A. & KIRKPATRICK, J.B. (1974) The phytosociology and synecology of some southern Tasmanian eucalypt forests and woodlands. Journal of Biogeography 1, 227-245.

HORN, H.S. (1974) The ecology of secondary succession. Annual Review of Ecology and Systematics 5, 25-37.

HULL, C.H. & NIE, N.H. (eds.) (1981) SPSS Update 7-9. McGraw-Hill, New York.

ISAAC, L.A. (1940) Vegetative succession following logging in the Douglas-fir region with special reference to fire. Journal of Forestry 38, 716-721.

JACKSON, W.D. (1968) Fire, air, water and earth - an elemental ecology of Tasmania. Proceedings of the Ecological Society of Australia 3, 9-16.

JACKSON, W.D. (1973) Vegetation of the Central Plateau. In: The Lake Country of Tasmania (ed. M.R. Banks), pp. 61-85. Royal Society of Tasmania, Hobart.

JACKSON, W.D. & BOWMAN, D.M.J.S. (1982) Slash-burning in Tasmanian dry eucalypt forests. Comment. Search 45, 63-67.

JACOBS, M.R. (1955) Growth Habits of the Eucalypts. Government Printer, Canberra.

JARRETT, P.H. & PETRIE, A.H.K. (1929) The vegetation of the Blacks' Spur region. A study in the ecology of some Australian mountain Eucalyptus forests. II. Pyric succession. Journal of Ecology 17, 249-281.

KILE, G.A. (1974) Insect defoliation in the eucalypt regrowth forests of southern Tasmania. Australian Forest Research 6, 9-18.

KING, N.K. & VINES, R.G. (1969) Variation in the flammability of the leaves of some Australian forest species. Commonwealth Scientific and Industrial Research Organisation, Division of Applied Chemistry Mimeographed Report.

KIRKPATRICK, J.B. (1981) A transect study of forests and woodland on dolerite in the Eastern Tiers, Tasmania. Vegetatio 44, 155-163.

KIRKPATRICK, J.B. (1982) Phytogeographical analysis of Tasmanian alpine floras. Journal of Biogeography 9, 255-271.

KIRKPATRICK, J.B. & BOWMAN, D.M.J.S. (1982) Clearfelling versus selective logging in uneven-aged eucalypt forest. Search 13, 136-141.

KIRKPATRICK, J.B., BROWN, M.J. & MOSCAL, A. (1980) Threatened Plants of the Tasmanian Central East Coast. Tasmanian Conservation Trust, Hobart.

KIRKPATRICK, J.B. & DICKINSON, K.J.M. (1982) Recent destruction of natural vegetation in Tasmania. Search 13, 186-187.

KIRKPATRICK, J.B. & DICKINSON, K.J.M. (1984) Vegetation map of Tasmania, 1:500,000. Forestry Commission, Tasmania.

KUBICEK, F. (1977) Energy values of selected species of the herbaceous layer and organic litter in the forest ecosystem. Biologia (Bratislava) 32, 505-515.

LEIGH, J.H. & HOLGATE, M.D. (1979) The responses of the understorey of forests and woodlands of the Southern Tablelands to grazing and burning. Australian Journal of Ecology 4, 25-45.

LEMON, P.C. (1949) Successional responses of herbs in the longleaf-slash pine forest after fire. Ecology 30, 135-145.

LEONARD, B. (1970) Effects of control burning on the ecology of small mammal populations. Papers of the 2nd Fire Ecology Symposium, Monash University, November 1970. Forests Commission, Victoria.

LOCKETT, E.J. & CANDY, S.G. (1984) Growth of eucalypt regeneration established with and without slash burns in Tasmania. Australian Forestry 47, 119-125.

LOYN, R.H. (1980) Bird populations in a mixed eucalypt forest used for the production of wood in Gippsland. Emu 80, 145-156.

LOYN, R.H., FAGG, P.C., PIGGIN, J.E., MORTON, A.G. & TOLHURST, K.G. (1983) Changes in the composition of understorey vegetation after harvesting eucalypts for sawlogs and pulpwood in East Gippsland. Australian Journal of Ecology 8, 43-53.

LOYN, R.H., MACFARLANE, M.H., CHESTERFIELD, E.A. & HARRIS, J.A. (1980) Forest utilisation and the flora and fauna in Boola Boola State Forest in south-eastern Victoria. Forests Commission, Victoria, Bulletin No. 28.

MAK, E.H.T. (1982) The relationship between the nutrient status and flammability of forest fuels. Ph.D. thesis, Australian National University.

MacARTHUR, R.H. (1964) Environmental factors affecting bird species diversity. American Naturalist 98, 387-397.

MacARTHUR, R.H. & MacARTHUR, J.W. (1961) On bird species diversity. Ecology 42, 594-598.

MARGALEF, R. (1963) Successions of populations. Advances in the Frontiers of Plant Science, Institute for the Advancement of Science and Culture, New Delhi, India 2, 137-188.

McARTHUR, A.G. (1962) Control burning in eucalypt forests. Commonwealth of Australia, Forestry and Timber Bureau Leaflet No. 80.

McBRIEN, H., HARMSEN, R. & CROWDER, A. (1983) A case of insect grazing affecting plant succession. Ecology 64, 1035-1039.

McCLELLAND, B.R. & FRISSELL, S.S. (1975) Identifying forest snags useful for hole-nesting birds. Journal of Forestry 73, 414-417.

McGEE, C.E. & HOOPER, R.M. (1975) Regeneration trends ten years after clearcutting of an Appalachian hardwood stand. United States Department of Agriculture, Forest Service Research Note SE-227.

McILROY, J.C. (1978) The effects of forestry practices on wildlife in Australia: a review. Australian Forestry 41, 78-94.

McNAB, W.H., EDWARDS, M.B.Jr. & HOUGH, W.A. (1978) Estimating fuel weights in slash pine-palmetto stands. Forest Science 24, 345-358.

MILES, J. (1981) Problems in heathland and grassland dynamics. Vegetatio 46, 61-74.

MINCHIN, P.R. (1984) ECOPACK - ecological data handling and analysis system. Department of Geography, University of Tasmania.

MOLLISON, B.C. (1960) Progress report on the ecology and control of marsupials in the Florentine Valley. Appita 14, xxi-xxvi.

MONTGOMERY, K.R. & CHEO, P.C. (1971) Effect of leaf thickness on ignitibility. Forest Science 17, 475-478.

MOONEY, H.A. & DUNN, E.L. (1970) Convergent evolution of mediterranean-climate evergreen sclerophyll shrubs. Evolution 24, 292-303.

MOORE, C.W.E. & KERATIS, K. (1971) Effect of nitrogen source on growth of Eucalyptus in sand culture. Australian Journal of Botany 19, 125-141.

MORRIS, W.G. (1958) Influence of slash-burning on regeneration, other plant cover, and fire hazard in the Douglas-fir region. United States Department of Agriculture, Forest Service Research Paper No. 29.

MOUNT, A.B. (1964) The interdependence of the eucalypts and forest fires in southern Australia. Australian Forestry 28, 166-172.

MOUNT, A.B. (1969) Eucalypt ecology as related to fire. Proceedings of the Tall Timbers Fire Ecology Conference 9, 75-108.

MOUNT, A.B. (1976) Some problems associated with small coupes. Search 7, 462.

MOUNT, A.B. (1979) Natural regeneration processes in Tasmanian eucalypt forests. Search 10, 180-186.

MUELLER-DOMBOIS, D. (1965) Initial stages of secondary succession in the coastal Douglas-fir and western hemlock zones. In: Ecology of Western North America, Vol. I. (ed. V.J. Krajina), pp. 38-41. University of British Colombia, Vancouver.

MUELLER-DOMBOIS, D. & ELLENBERG, H. (1974) Aims and Methods of Vegetation Ecology. Wiley & Sons, New York.

MUTCH, R.W. (1970) Wildland fires and ecosystems - a hypothesis. Ecology 51, 1046-1051.

MUTCH, R.W. & PHILPOT, C.W. (1970) Relation of silica content to flammability in grasses. Forest Science 16, 64-65.

NAVEH, Z. (1975) The evolutionary significance of fire in the mediterranean region. Vegetatio 29, 199-208.

NEEDHAM, R.H. (1960) Problems associated with the regeneration of Eucalyptus gigantea in the Surrey Hills area. Appita 13, 139-140.

NEFF, D.J. (1968) The pellet group count technique for big game trend, census and distribution: a review. Journal of Wildlife Management 32, 597-614.

NIE, N.H., HULL, C.H., JENKINS, J.G., STEINBRENNER, K. & BENT, D.H. (eds.) (1975) SPSS. Statistical Package for the Social Sciences, 2nd edn. McGraw-Hill, New York.

NIELSEN, W.A. & ELLIS, R.A. (1981) Slash burning on forest sites, further comment. Search 12, 9-10.

NOBLE, I.R. & SLATYER, R.O. (1981) Concepts and models of succession in vascular plant communities subject to recurrent fire. In: Fire and the Australian Biota (eds. A.M. Gill, R.H. Groves & I.R. Noble), pp. 311-335. Australian Academy of Science, Canberra.

ODUM, E.P. (1971) Fundamentals of Ecology, 3rd edn. Saunders, Philadelphia.

OHMART, C.P., STEWART, L.G. & THOMAS, J.R. (1983) Phytophagous insect communities in the canopies of three Eucalyptus forest types in south-eastern Australia. Australian Journal of Ecology 8, 395-403.

ORME, R.K. (1971) The regeneration of commercial eucalypt forests on Surrey Hills, N.W. Tasmania. M.Sc. thesis, University of Tasmania.

PARKER, G.R. & SWANK, W.T. (1982) Tree species response to clear-cutting a southern Appalachian watershed. American Midland Naturalist 108, 304-310.

PATTEMORE, V. (1980) Effects of the pulpwood industry on wildlife in Tasmania. 3. Succession in bird communities and their habitats. National Parks and Wildlife Service, Tasmania, Wildlife Division Technical Report 80/1.

PATTEMORE, V. & KIKKAWA, J. (1975) Comparison of bird populations in logged and unlogged rainforest at Wiangarie State Forest, N.S.W.. Australian Forestry 37, 188-198.

PEET, G.B. (1965) A fire danger rating and controlled burning guide for the northern jarrah (Euc. marginata Sm.) forest of Western Australia. Forests Department, Western Australia, Bulletin No. 74.

PEET, G.B. (1971) A study of scrub fuels in the jarrah forest of Western Australia. Forests Department, Western Australia, Bulletin No. 80.

PEET, R.K. (1974) The measurement of species diversity. Annual Review of Ecology and Systematics 5, 285-307.

PETERS, D.G. (1985) TASFORHAB. In: Survey Methods for Nature Conservation, Vol. II. (ed. K. Myers, C.R. Margulles & I. Musto). Commonwealth Scientific and Industrial Research Organisation, Division of Water and Land Resources, Canberra (in press).

PHILPOT, C.W. (1970) Influence of mineral content on the pyrolysis of plant materials. Forest Science 16, 461-471.

PHILPOT, C.W. (1977) Vegetative features as determinants of fire frequency and intensity. United States Department of Agriculture, Forest Service General Technical Report WO-3.

POMPE, A. & VINES, R.G. (1966) The influence of moisture on the combustion of leaves. Australian Forestry 30, 231-241.

POSAMENTIER, H.G., CLARK, S.S., HAIN, D.L. & RECHER, H.F. (1981) Succession following wildfire in coastal heathland (Nadgee Nature Reserve N.S.W.). Australian Journal of Ecology 6, 165-175.

PRYOR, L.D. (1960) The 'ash-bed' effect in Eucalyptus ecology. Institute of Foresters of Australia Newsletter 2, 23-26.

PRYOR, L.D. (1963) Ashbed growth response as a key to plantation establishment. Australian Forestry 27, 48-51.

PURDIE, R.W. (1976) Ecological succession after burning in dry sclerophyll vegetation. Ph.D. thesis, Australian National University.

PURDIE, R.W. (1977a) Early stages of regeneration after burning in dry sclerophyll vegetation. I. Regeneration of the understorey by vegetative means. Australian Journal of Botany 25, 21-34.

PURDIE, R.W. (1977b) Early stages of regeneration after burning in dry sclerophyll vegetation. II. Regeneration by seed germination. Australian Journal of Botany 25, 35-46.

PURDIE, R.W. & SLATYER, R.O. (1976) Vegetation succession after fire in sclerophyll woodland communities in south-eastern Australia. Australian Journal of Ecology 1, 223-236.

QUARTERMAN, E. (1957) Early plant succession on abandoned cropland in the Central Basin of Tennessee. Ecology 38, 300-309.

RADWAN, M.A. (1974) Natural resistance of plants to mammals. In: Wildlife and Forest Management in the Pacific Northwest (ed. H.C. Black), pp. 85-93. School of Forestry, Oregon State University, Corvallis, Oregon.

RAINE, C.I. (1984) The eco-physiology of understorey shrubs on a wet-dry sclerophyll interface, south-east Tasmania. Honours thesis, University of Tasmania.

RAISON, R.J. (1980) Possible site deterioration associated with slash-burning. Search 11, 68-72.

RAISON, R.J. (1981) More on the effects of intense fires on the long-term productivity of forest sites: reply to comments. Search 12, 10-14.

RAISON, R.J., WOODS, P.V. & KHANNA, P.K. (1983) Dynamics of fine fuels in recurrently burnt eucalypt forests. Australian Forestry 46, 294-302.

RATKOWSKY, A.V. & RATKOWSKY, D.A. (1977) The birds of the Mt. Wellington Range, Tasmania. Emu 77, 19-22.

RATKOWSKY, A.V. & RATKOWSKY, D.A. (1979) A comparison of counting methods to obtain bird species numbers. Notornis 26, 53-61.

RECHER, H.F. (1971) Bird species diversity: a review of the relation between species number and environment. Proceedings of the Ecological Society of Australia 6, 135-152.

RECHER, H.F., LUNNEY, D., SMITH, P. & ROHAN-JONES, W. (1981) Woodchips or wildlife? Australian Natural History 20, 239-244.

ROTHERMEL, R.C. (1972) A mathematical model for predicting fire spread in wildland fuels. United States Department of Agriculture, Forest Service Research Paper INT-115.

RUNDEL, P.W. (1981) Structural and chemical components of flammability. In: Fire Regimes and Ecosystem Properties - Proceedings of the Conference, Hawaii, 1978. United States Department of Agriculture, Forest Service General Technical Report WO-26, 183-207.

RUSSELL, R.P. & PARSONS, R.F. (1978) Effects of time since fire on heath floristics at Wilson's Promontory, southern Australia. Australian Journal of Botany 26, 53-61.

SCHODDE, R., GLOVER, B., KINSKY, F.C., MARCHANT, S., McGILL, A.R. & PARKER, S.A. (1977) Recommended English names for Australian birds. Emu 77, 245-307.

SELKIRK, P.M., COSTIN, A.B., SEPPELT, R.D. & SCOTT, J.J. (1983) Rabbits, vegetation and erosion on Macquarie Island. Proceedings of the Linnaean Society of New South Wales 106, 337-346.

SHAFI, M.I. & YARRANTON, G.A. (1973) Diversity, floristic richness, and species evenness during a secondary (post-fire) succession. Ecology 54, 897-902.

SHAFIZADEH, F. (1968) Pyrolysis and combustion of cellulosic fuels. Advances in Carbohydrate Chemistry 23, 419-474.

SHAFIZADEH, F., CHIN, P.P.S. & DeGROOT, W.F. (1977) Effective heat content of green forest fuels. Forest Science 23, 81-89.

SHANNON, C.E. & WEAVER, W. (1949) The Mathematical Theory of Communication. University of Illinois Press, Urbana, Illinois.

SHEA, S.R., McCORMICK, J. & PORTLOCK, C.C. (1979) The effects of fires on regeneration of leguminous species in the northern jarrah (Eucalyptus marginata Sm.) forest of Western Australia. Australian Journal of Ecology 4, 195-205.

SINGH, J.S. & YADAVA, P.S. (1973) Caloric values of plant and insect species of a tropical grassland. Oikos 24, 186-194.

SINGH, R.P. (1980) Energy dynamics in Eucalyptus tereticornis Smith plantations in Western Uttar Pradesh. Indian Forester 106, 649-658.

SNEEUWJAGT, R.J. (1973) Measuring forest fuels. Forests Department, Western Australia, Research Paper No. 9.

SNEEUWJAGT, R.J. & PEET, G.B. (1979) Forest Fire Behaviour Tables for Western Australia, revised edn. Forests Department, Western Australia.

SPECHT, R.L. (1969a) A comparison of the sclerophyllous vegetation characteristic of mediterranean type climates in France, California and Australia. I. Structure, morphology and succession. Australian Journal of Botany 17, 277-292.

SPECHT, R.L. (1969b) A comparison of the sclerophyllous vegetation characteristic of mediterranean type climates in France, California and Australia. II. Dry matter, energy and nutrient accumulation. Australian Journal of Botany 17, 293-308.

SPECHT, R.L., RAYSON, P. & JACKMAN, M.E. (1958) Dark Island Heath (Ninety-Mile Plain, South Australia). VI. Pyric succession: changes in composition, coverage, dry weight and mineral nutrient status. Australian Journal of Botany 6, 59-88.

SPRINGETT, B.P. (1978) On the ecological role of insects in Australian eucalypt forests. Australian Journal of Ecology 3, 129-139.

STATHAM, H.L. (1983) Browsing damage in Tasmanian forest areas and effects of 1080 poisoning. Forestry Commission, Tasmania, Bulletin No. 7.

STATHAM, H.L. (1984) The effects of forest operations on wildlife in Tasmania. Report for the Forest Ecology Research Fund, Tasmania.

STEEN, H.K. (1966) Vegetation following slash fires in one western Oregon locality. Northwest Science 40, 113-120.

TAYLOR, R.H. (1956) The use of pellet counts for estimating the density of populations of the wild rabbit, Oryctolagus cuniculus (L.). New Zealand Journal of Science and Technology 38(B), 236-256.

TAYLOR, R.J. (1980) Distribution of feeding activity of the Eastern Grey Kangaroo, Macropus giganteus, in coastal lowland of south-east Queensland. Australian Wildlife Research 7, 317-325.

THOMAS, D.G. (1979) Tasmanian Bird Atlas. Fauna of Tasmania Handbook No. 2, University of Tasmania, Hobart.

THOMAS, D.G. (1980) Foraging of honeyeaters in an area of Tasmanian sclerophyll forest. Emu 80, 55-58.

TRABAUD, L. (1976) Inflammabilité et combustibilité des principales espèces des garrigues de la région méditerranéene. Oecologia Plantarum 11, 117-136.

TRIGGS, B. (1984) Mammal Tracks and Signs. A Fieldguide for South-eastern Australia. Oxford University Press, Melbourne.

TUNSTALL, B.R., MARTIN, T., WALKER, J., GILL, A.M. & ASTON, A. (1976) Soil temperatures induced by an experimental log pile fire: preliminary data analysis. Commonwealth Scientific and Industrial Research Organisation, Division of Land Use Research Technical Memorandum 76/20.

TURNER, J. & LAMBERT, M.J. (1980) Slash burning on forest sites. Search 11, 316-317.

UHL, C., CLARK, K., CLARK, H. & MURPHY, P. (1981) Early plant succession after cutting and burning in the Upper Rio Negro region of the Amazon Basin. Journal of Ecology 69, 631-649.

VAN LOON, A.P. (1969) Investigations into the effects of prescribed burning on young even aged blackbutt. Forestry Commission, New South Wales, Research Note 23.

VAN LOON, A.P. (1977) Bushland fuel quantities in the Blue Mountains - litter and understorey. Forestry Commission, New South Wales, Research Note 33.

VINES, R.G. (1968) Heat transfer through bark and the resistance of trees to fire. Australian Journal of Botany 16, 499-514.

WAGENER, W.W. & OFFORD, H.R. (1972) Logging slash : its breakdown and decay at two forests in northern California. United States Department of Agriculture, Forest Service Research Paper PSW-83.

WARCUP, J.H. (1980) Effect of heat treatment of forest soil on germination of buried seed. Australian Journal of Botany 28, 567-571.

WELLS, K.F., GOWLAND, P.N. & SPATE, A.P. (1977) Natural resources of the Buckland Training Area, Tasmania. Commonwealth Scientific and Industrial Research Organisation, Division of Land Use Research Technical Memorandum 77/14.

WEST, N.E. & CHILCOTE, W.W. (1968) Senecio sylvaticus in relation to Douglas-fir clear-cut succession in the Oregon Coast Range. Ecology 49, 1101-1107.

WHITFORD, P.C. & WHITFORD, P.B. (1978) Effects of trees on ground cover in old-field succession. American Midland Naturalist 99, 435-443.

WHITTAKER, R.H. (1953) A consideration of climax theory: the climax as a population and pattern. Ecological Monographs 23, 41-78.

WILLIS, J.H. (1970) A Handbook to Plants in Victoria, Vol. I, 2nd edn. Melbourne University Press, Melbourne.

WILSON, R.I. (1981) The woodchip industry and Tasmanian birds. Tasmanian Bird Report No. 11, 11-14.

WILSON, A.D., LEIGH, J.H., HINDLEY, N.L. & MULHAM, W.E. (1975) Comparison of the diets of goats and sheep on a Casuarina cristate - Heterodendrum oleifolium woodland community in western New South Wales. Australian Journal of Experimental Agriculture and Animal Husbandry 15, 45-53.

WITHERS, J. & ASHTON, D.H. (1977) Studies on the status of unburnt *Eucalyptus* woodland at Ocean Grove, Victoria. I. The structure and regeneration. *Australian Journal of Botany* *25*, 623-637.

WOINARSKI, J.C.Z. (1979) Birds of a *Eucalyptus* plantation and adjacent natural forest. *Australian Forestry* *42*, 243-247.

APPENDICES

APPENDIX 1:- Rainfall figures for MM14, Nugent and Hobart airport, during 2 years of the study period. NA: data not available; A: total rainfall for recording periods when figures available for Nugent: (A) total for all recording periods.

YEAR	PERIOD	RAINFALL (mm)		
		MM14 (mean)	Nugent	Hobart Airport
1982	September 15 - 19	2.0	0.0	8.0
	19 - 23	0.0	0.0	0.0
	23 - 27	4.5	3.6	1.4
	27 - 30	16.0	25.4	9.2
	30 -			
	October 2	0.0	0.0	3.4
	2 - 5	0.5	0.0	0.6
	5 -			
	November 1	21.0	14.7	4.6
	1 - 11	16.5	NA	18.4
	11 - 18	1.5	NA	3.0
	18 -			
	December 6	4.0	NA	5.6
	6 - 19	34.0	24.4	8.6
	19 -			
1983	January 8	11.5	19.6	5.8
	8 - 13	5.5	11.6	2.0
	13 -			
	February 3	21.5	19.6	14.6
	3 -			
	March 1	20.5	6.0	7.6
	1 - 15	41.0	20.0	29.4
	15 -			
	April 8	112.5	77.6	84.8
	8 - 13	17.0	17.1	11.0
	13 - 18	45.0	38.3	8.0
	18 - 29	57.5	59.6	29.6
	29 -			
	May 5	3.5	4.2	1.2
	5 - 6	9.0	8.0	11.2
	6 - 11	1.5	2.2	0.0
	11 - 19	5.5	5.0	2.2
	19 -			
	June 18	52.0	29.8	41.2
	18 - 22	0.8	2.0	0.0
	22 - 28	17.0	20.2	8.6
	28 -			
	July 3	31.5	39.6	17.4
	3 - 9	32.5	14.0	8.0
	9 -			
	August 3	22.5	14.0	8.0
	3 -			
	September 10	117.5	168.6	123.0
	10 -			
	October 5	30.0	35.2	62.4
	5 - 20	89.0	53.6	40.6
	20 -			
	November 7	16.0	13.8	8.8
	7 -			
	December 17	89.0	73.2	71.6
	17 -			
1984	January 4	4.5	0	2.0
	4 - 10	17.5	10.4	4.4
	10 - 13	5.5	4.2	0.0
	13 - 17	1.5	6.0	0.4
	17 - 21	0.5	3.1	0.0
	21 -			
	February 7	6.0	14.8	5.8
	7 - 19	17.5	0.0	4.8
	19 -			
	March 1	28.5	37.2	11.2
	1 - 24	19.0	24.6	8.4
	24 -			
	April 3	17.5	22.8	12.2
	3 - 5	1.0	0.0	0.2
	5 - 28	35.5	25.2	39.8
	28 -			
	May 1	0.0	NA	0.0
	1 -			
	June 19	27.5	NA	36.6
	19 -			
	July 12	39.0	NA	7.2
	12 -			
	August 8	157.0	NA	104.8
	8 - 22	174.5	NA	55.6
	22 -			
	September 13	38.0	NA	17.6
TOTAL	A	1081.8	979.2	722.0
	(A)	(1539.8)	(NA)	(970.8)

APPENDIX 2: - List of species, including those of rare occurrence, recorded in the selected permanent quadrats on treatment B (before and after slash-burn), treatment UB, and C, in both vegetation types, P & O. (1) records from initial floristic survey (2) species present during the 24 months of records taken after the time of slash-burn.
NA: record available at generic level only.

Life form	Species	TYPE P						TYPE O					
		B: pre-burn	B: post-burn	UB (1)	UB (2)	C (1)	C (2)	B: pre-burn	B: post-burn	UB (1)	UB (2)	C (1)	C (2)
S	Acacia dealbata	X	X	X	X	X	X	X	X	X	X	X	X
S	Acacia genistifolia	-	-	-	-	-	-	X	-	-	-	-	-
S	Acacia stricta	X	X	X	X	X	X	X	X	X	X	X	X
H	Acaena agnipila	-	-	-	-	-	-	-	-	-	-	X	-
H	Acaena echinata	-	X	-	-	-	-	-	X	-	-	-	-
H	Acaena novae-zelandiae	-	X	-	-	-	-	-	X	-	X	X	X
S	Acrotriche serrulata	-	-	-	-	X	-	-	-	-	-	-	-
O	Acianthus caudatus	-	-	X	X	-	X	-	-	-	X	-	-
G	Agrostis spp.	X	X	X	X	X	X	-	X	-	-	-	-
G	Agrostis aemula	NA	X	NA	X	NA	X	-	X	-	-	-	-
G	Agrostis parviflora	NA	X	NA	X	NA	X	-	X	-	-	-	-
G	Agrostis venusta	NA	X	NA	X	NA	X	-	X	-	-	-	-
Gr	Anguillaria uniflora	-	-	-	-	-	-	-	-	X	-	-	-
Gr	Arthropodium milleflorum	X	X	X	X	X	X	X	X	X	X	-	X
F	Asplenium flabellifolium	-	X	-	-	-	-	-	X	-	X	X	-
S	Astroloma humifusum	X	X	X	X	X	X	X	X	X	X	-	X
S	Bossiaea prostrata	X	X	X	X	X	X	-	-	-	-	X	-
H	Brachycome scapiformis	X	-	-	-	-	X	-	-	X	X	-	-
Gr	Bulbine bulbose	-	X	X	-	-	-	-	X	-	-	-	-
O	Caladenia catenata	X	-	-	-	-	-	-	-	-	-	-	-
Gr	Carex breviculmis	X	X	X	X	X	X	-	X	-	-	-	-
O	Chiloglottis spp.	-	-	-	-	-	X	-	-	-	X	X	X
H	Cirsium vulgare	X	X	X	X	X	X	X	X	X	X	-	X
Cl	Comesperma volubile	-	-	-	-	X	X	-	-	-	X	X	X
S	Coprosma quadrifida	-	-	-	-	-	-	-	-	-	-	X	X
O	Corybas spp.	-	-	-	X	X	X	-	-	X	X	-	X
H	Craspedia glauca	X	-	X	X	X	X	-	X	X	X	-	-
H	Crepis sp.	-	-	-	-	-	X	-	X	-	-	-	-
S	Cyathodes divaricata	-	-	-	-	-	-	-	-	-	-	-	X
S	Cyathodes glauca	X	-	-	-	-	-	X	X	X	X	X	X
G	Danthonia spp.	X	X	X	X	X	X	X	X	X	X	X	X
S	Daviesia ulicifolia	-	-	X	X	-	-	-	-	-	-	-	X
G	Deyeuxia spp.	X	X	X	X	X	X	X	X	X	X	X	X
Gr	Dianella revoluta	-	-	-	-	X	X	-	-	-	X	-	-
Gr	Dianella tasmanica	-	-	-	-	-	X	-	X	X	X	-	-
Gr	Diplarrena moraea	X	X	X	X	X	X	X	X	X	X	X	X
O	Diuris pedunculata	-	-	-	-	-	-	-	-	-	X	-	-
H	Drosera auriculata	X	X	X	X	X	X	X	X	X	X	-	X
Gr	Drymophila cyanocarpa	-	-	-	-	-	-	-	X	-	X	-	X
S	Epacris impressa	X	X	X	X	X	X	X	X	X	X	X	X
H	Epilobium sarmentaceum	-	X	-	-	-	-	-	X	-	X	-	-
O	Eriochilus cucullatus	-	X	-	X	-	X	-	X	-	X	-	-
T	Eucalyptus amygdalina	X	X	X	X	X	X	-	-	-	X	-	-
T	Eucalyptus globulus	-	-	-	-	-	-	-	-	-	-	X	X
T	Eucalyptus obliqua	-	X	X	X	-	-	-	X	X	X	X	X
T	Eucalyptus pulchella	X	X	X	-	-	-	-	X	-	-	-	-
T	Eucalyptus viminalis	-	-	-	-	X	X	-	-	X	X	-	-
G	Festuca asperula	X	X	X	X	X	X	X	X	X	X	X	X
Gr	Gahnia grandis	-	X	-	-	-	X	X	X	-	X	X	X
H	Galium albescens	-	X	-	X	-	-	-	-	-	-	-	-
H	Galium australe	-	X	-	X	-	-	-	X	-	X	X	X
H	Geranium potentilloides	-	-	-	-	-	-	-	X	-	-	-	-

APPENDIX 2: Cont'd

Life form	Species	TYPE P: B: pre-burn	TYPE P: B: post-burn	TYPE P: UB (1)	TYPE P: UB (2)	TYPE P: C (1)	TYPE P: C (2)	TYPE O: B: pre-burn	TYPE O: B: post-burn	TYPE O: UB (1)	TYPE O: UB (2)	TYPE O: C (1)	TYPE O: C (2)
H	Gnaphalium collinum	-	X	-	X	-	X	X	X	X	X	X	X
H	Goodenia lanata	X	X	X	X	X	X	X	X	X	X	X	X
S	Goodenia ovata	-	-	-	-	-	-	-	-	-	-	X	X
H	Haloragis tetragyna	X	X	X	X	X	X	X	X	X	X	X	X
H	Haloragis teucrioides	X	X	-	X	-	-	-	X	X	-	X	X
H	Helichrysum dealbatum	-	-	X	X	-	-	-	X	-	-	-	-
H	Helichrysum scorpioides	X	X	X	X	X	X	X	X	X	X	X	X
S	Helichrysum thyrsoideum	-	X	-	X	-	X	-	X	-	X	X	X
S	Hovea heterophylla	-	-	-	-	-	X	-	-	-	-	-	-
H	Hydrocotyle javanica	-	X	-	X	-	-	X	X	X	X	X	X
H	Hypericum gramineum	X	X	X	X	X	X	X	X	X	X	X	X
H	Hypochaeris radicata	-	X	X	X	-	X	-	X	-	X	-	-
H	Lagenophora stipitata	X	X	X	X	X	X	X	X	X	X	X	X
Gr	Lepidosperma laterale	X	-	-	-	X	X	X	X	X	X	-	-
Gr	Lepidosperma lineare var. inops	-	-	-	-	X	X	-	-	-	-	-	-
H	Leptorhyncos squamatus	-	-	X	X	-	X	-	-	-	-	-	-
S	Leptospermum scoparium	X	X	X	X	X	X	X	X	X	X	X	X
H	Leontodon leysseri	-	X	-	X	-	X	-	X	-	X	-	X
S	Lissanthe strigosa	X	X	X	X	X	X	-	-	-	-	-	-
	Liverwort	-	X	-	-	-	-	-	X	-	-	-	-
Gr	Lomandra longifolia	X	X	X	X	X	X	X	X	X	X	X	X
S	Lomatia tinctoria	X	X	-	X	X	X	X	X	X	X	X	X
Gr	Luzula spp.	-	X	-	-	-	-	-	X	-	-	-	-
S	Marianthus procumbens	X	X	-	-	-	-	-	-	-	-	-	-
G	Microlaena stipoides	X	X	X	X	X	X	X	X	X	X	X	X
O	Microtis unifolia	-	-	-	-	-	-	-	-	-	X	-	-
	Moss	-	X	-	-	-	-	-	X	-	-	-	-
S	Olearia erubescens	X	X	-	X	X	X	-	X	-	X	-	-
S	Olearia spp.	-	X	-	X	-	-	-	X	-	X	X	X
S	Olearia ramulosa	-	X	-	-	-	X	-	X	-	-	-	-
H	Opercularia varia	-	X	-	X	X	X	-	X	-	X	-	X
H	Oxalis corniculata	-	X	X	X	X	X	-	X	-	-	-	X
G	Pentapogon/Dichelachne	X	X	X	X	X	X	X	X	X	X	-	X
S	Pimelea humilis	X	X	X	X	-	X	-	-	-	X	-	-
H	Plantago varia	X	X	X	X	X	X	-	-	-	-	-	-
G	Poa spp.	X	X	X	X	X	X	X	X	X	X	X	X
G	Poa labillardieri	NA	X	NA	X	NA	X	NA	X	NA	X	NA	X
G	Poa rodwayi	NA	X	NA	X	NA	X	-	-	-	-	-	-
H	Poranthera microphylla	-	-	-	X	X	X	-	-	X	X	X	X
H	Pratia pedunculata	-	-	-	-	-	X	X	X	-	X	-	-
F	Pteridium esculentum	X	-	-	-	X	X	X	X	X	X	X	X
O	Pterostylis longiflora	-	-	-	-	-	X	X	X	-	X	-	X
S	Pultenaea juniperina	X	X	X	X	-	-	X	X	X	X	X	X
H	Ranunculus lappaceus	-	X	-	-	-	-	-	-	-	-	-	-
Gr	Schoenus apogon	X	X	X	X	X	X	X	X	-	X	X	-
H	Senecio spp.	-	-	-	-	-	-	X	-	X	-	-	-
H	Senecio minimus	-	X	-	X	-	X	-	X	-	X	-	-
H	Sonchus asper	-	X	-	-	-	-	-	X	-	-	-	-
H	Sonchus oleraceus	-	-	-	-	-	-	X	-	-	-	-	-
G	Stipa spp.	X	X	X	X	X	X	-	X	X	X	X	-
G	Stipa pubinodis	NA	X	-	-	NA	X	-	X	-	-	-	-
H	Stylidium graminifolium	-	X	X	X	-	X	-	-	-	-	-	X
G	Tetrarrhena distichophylla	-	-	-	-	X	X	-	-	-	-	-	-
S	Tetratheca glandulosa	-	-	-	-	-	X	-	-	X	X	X	X
S	Tetratheca procumbens	-	-	-	-	-	X	-	-	-	-	-	-
G	Themeda australis	-	-	-	X	X	X	X	-	-	-	-	-
H	Viola hederacea	X	X	X	X	X	X	X	X	X	X	X	X
H	Wahlenbergia spp.	X	X	X	X	X	X	X	X	X	X	X	X

Appendix 3.1

APPENDIX 3

Mean percentage cover through time of species on the permanent plots in each vegetation type, treatment and control. (see Chapter 2; section 2.5.2.2). NA = data not available.

			Mean percentage cover - type P						Mean percentage cover - type O					
			Time since slash-burn (months)											
Group	Treatment /control	Species	1	2	4	8	16/17	24	1	2	4	8	16/17	24
1(i)	B	Agrostis parviflora	0.02	0.03	0.04	0.05	0.10	0.18	0.01	0.01	0.01	0.02	0.04	0.34
	UB	Agrostis parviflora	NA	NA	NA	0.02	0.02	0.03	NA	NA	-	-	-	-
	C	Agrostis parviflora	NA	NA	NA	0.02	0.02	0.01	NA	NA	-	-	-	-
	B	Agrostis venusta	0.01	0.01	0.01	0.02	0.03	0.15	-	-	-	-	-	0.01
	UB	Agrostis venusta	NA	NA	NA	-	-	0.01	NA	NA	-	-	-	-
	C	Agrostis venusta	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	B	Gnaphalium collinum	-	-	0.02	0.18	0.25	0.41	0.01	0.02	0.03	0.10	0.15	0.26
	UB	Gnaphalium collinum	NA	NA	NA	0.03	0.05	0.05	NA	NA	0.02	0.05	0.04	0.04
	C	Gnaphalium collinum	NA	NA	NA	0.03	0.02	0.02	NA	NA	0.05	0.05	0.02	0.03
	B	Lomandra longifolia	0.30	0.60	1.10	2.10	6.90	7.60	0.20	0.20	0.80	1.60	3.60	4.10
	UB	Lomandra longifolia	NA	NA	NA	1.80	1.80	2.10	NA	NA	2.70	3.60	3.80	3.80
	C	Lomandra longifolia	NA	NA	NA	12.80	12.60	12.80	NA	NA	10.60	11.10	11.70	11.70
	B	Lomatia tinctoria	0.02	0.02	0.10	0.20	0.30	0.90	0.08	0.08	0.09	0.15	0.20	0.60
	UB	Lomatia tinctoria	NA	NA	NA	0.02	0.01	-	NA	NA	1.41	1.80	1.88	1.95
	C	Lomatia tinctoria	NA	NA	NA	0.70	0.64	0.64	NA	NA	2.00	2.07	2.07	2.00
	B	Schoenus apogon	0.01	0.02	0.04	0.11	1.01	1.96	-	-	0.05	0.16	0.26	1.71
	UB	Schoenus apogon	NA	NA	NA	0.05	0.06	0.14	NA	NA	0.05	0.10	0.15	0.20
	C	Schoenus apogon	NA	NA	NA	0.05	0.05	0.06	NA	NA	-	-	-	-
	B	Senecio minimus	-	0.01	0.01	0.10	0.40	1.60	-	0.01	0.01	0.10	1.75	7.40
	UB	Senecio minimus	NA	NA	NA	-	-	0.02	NA	NA	0.10	0.10	0.10	0.10
	C	Senecio minimus	NA	NA	NA	-	-	0.02	NA	NA	-	-	-	-
	B	Stipa spp.	0.03	0.03	0.03	0.04	0.05	0.38	-	-	-	-	-	0.06
	UB	Stipa spp.	NA	NA	NA	0.03	0.06	0.03	NA	NA	0.02	0.01	-	-
	C	Stipa spp.	NA	NA	NA	0.06	0.02	0.05	NA	NA	-	-	-	-
	B	Viola hederacea	0.06	0.10	0.13	0.21	0.41	0.78	0.02	0.14	0.16	0.25	0.56	1.09
	UB	Viola hederacea	NA	NA	NA	0.10	0.10	0.12	NA	NA	0.77	0.95	0.76	0.91
	C	Viola hederacea	NA	NA	NA	0.36	0.26	0.26	NA	NA	0.22	0.28	0.22	0.22
1(ii)	B	Pteridium esculentum	0.02	0.03	0.09	0.10	0.54	1.22	0.10	0.20	0.60	0.70	1.60	3.20
	UB	Pteridium esculentum	NA	NA	NA	-	-	-	NA	NA	0.80	0.90	0.75	0.80
	C	Pteridium esculentum	NA	NA	NA	1.52	1.02	1.56	NA	NA	6.80	4.60	4.00	6.30
1(iii)	B	Agrostis aemula	0.01	0.01	0.01	0.02	0.03	0.19	-	0.01	0.02	0.03	0.04	0.12
	UB	Agrostis aemula	NA	NA	NA	0.01	0.08	0.13	NA	NA	-	-	-	-
	C	Agrostis aemula	NA	NA	NA	-	0.01	0.02	NA	NA	-	-	-	-
	B	Cirsium vulgare	0.03	0.03	0.05	0.07	0.23	0.25	0.01	0.03	0.06	0.09	0.33	0.46
	UB	Cirsium vulgare	NA	NA	NA	0.01	0.01	0.01	NA	NA	0.05	0.07	0.10	0.16
	C	Cirsium vulgare	NA	NA	NA	0.01	0.01	0.01	NA	NA	0.05	0.07	0.10	0.16
	B	Eucalyptus obliqua	-	-	0.01	0.01	0.04	0.08	-	-	0.02	0.05	0.38	0.98
	UB	Eucalyptus obliqua	NA	NA	NA	0.08	0.13	0.13	NA	NA	0.06	0.04	0.14	0.13
	C	Eucalyptus obliqua	NA	NA	NA	-	-	-	NA	NA	2.98	3.00	2.98	3.01
	B	Gahnia grandis	0.05	0.05	0.05	0.05	0.10	0.10	0.05	0.70	2.30	4.10	7.80	8.80
	UB	Gahnia grandis	NA	NA	NA	-	-	-	NA	NA	-	-	0.05	-
	C	Gahnia grandis	NA	NA	NA	-	0.05	-	NA	NA	3.25	3.80	4.60	5.10
	B	Hypochaeris radicata	0.01	0.02	0.02	0.06	0.08	0.19	0.02	0.02	0.04	0.09	0.12	0.18
	UB	Hypochaeris radicata	NA	NA	NA	0.01	0.02	0.04	NA	NA	-	0.01	-	0.01
	C	Hypochaeris radicata	NA	NA	NA	-	-	-	NA	NA	-	-	-	-

APPENDIX 3 CONT.

Group	Treatment /control	Species	Mean percentage cover - type P						Mean percentage cover - type O					
			Time since slash-burn (months)											
			1	2	4	8	16/17	24	1	2	4	8	16/17	24
1(iv)	B	Danthonia spp.	0.11	0.22	0.26	0.36	0.36	0.66	0.05	0.06	0.11	0.19	0.40	0.59
	UB	Danthonia spp.	NA	NA	NA	0.80	0.72	0.91	NA	NA	0.44	0.47	0.57	0.81
	C	Danthonia spp.	NA	NA	NA	0.03	0.03	0.04	NA	NA	0.11	0.19	0.15	0.19
	B	Haloragis tetragyna	0.16	0.21	0.30	0.30	0.46	1.10	0.03	0.13	0.15	0.15	0.36	0.55
	UB	Haloragis tetragyna	NA	NA	NA	0.54	0.51	1.00	NA	NA	0.48	0.32	0.32	0.60
	C	Haloragis tetragyna	NA	NA	NA	0.25	0.14	0.21	NA	NA	0.15	0.15	0.10	0.09
	B	Plantago varia	0.18	0.46	0.95	0.95	0.96	1.78	-	-	-	-	-	-
	UB	Plantago varia	NA	NA	NA	0.36	0.30	0.51	NA	NA	-	-	-	-
	C	Plantago varia	NA	NA	NA	0.16	0.31	0.51	NA	NA	-	-	-	-
1(v)	B	Pentapogon/Dichelachne	0.05	0.06	0.13	0.52	0.75	0.75	0.02	0.02	0.05	0.15	0.26	0.79
	UB	Pentapogon/Dichelachne	NA	NA	NA	0.41	0.72	0.80	NA	NA	0.18	0.28	0.35	0.35
	C	Pentapogon/Dichelachne	NA	NA	NA	0.20	0.25	0.21	NA	NA	0.18	0.18	0.25	0.18
2(i)	B	Poa spp.	0.80	1.10	1.50	2.10	3.10	4.50	0.40	0.40	0.50	0.60	1.10	1.60
	UB	Poa spp.	NA	NA	NA	21.60	25.30	24.50	NA	NA	3.80	4.60	4.60	4.70
	C	Poa spp.	NA	NA	NA	11.20	9.80	9.90	NA	NA	6.10	6.70	7.00	6.70
2(ii)	B	Hydrocotyle javanica	-	-	-	0.06	0.04	0.08	-	0.03	0.05	0.09	0.18	0.23
	UB	Hydrocotyle javanica	NA	NA	NA	-	0.01	-	NA	NA	0.28	0.45	0.55	0.94
	C	Hydrocotyle javanica	NA	NA	NA	-	-	-	NA	NA	0.02	0.02	0.02	0.02
2(iii)	B	Acacia dealbata	0.10	0.20	0.25	0.25	0.70	1.30	0.10	0.20	0.20	0.20	0.20	0.10
	UB	Acacia dealbata	NA	NA	NA	10.60	9.25	9.25	NA	NA	3.60	3.30	3.50	3.50
	C	Acacia dealbata	NA	NA	NA	6.80	6.70	6.70	NA	NA	2.60	2.90	3.00	3.20
	B	Deyeuxia spp.	0.09	0.09	0.09	0.10	0.26	0.31	0.01	0.01	0.01	0.02	0.10	0.12
	UB	Deyeuxia spp.	NA	NA	NA	0.20	0.27	0.45	NA	NA	0.30	0.28	0.22	0.30
	C	Deyeuxia spp.	NA	NA	NA	0.20	0.16	0.21	NA	NA	0.16	0.25	0.22	0.30
	B	Helichrysum scorpioides	0.05	0.06	0.09	0.12	0.15	0.28	0.05	0.05	0.05	0.05	0.06	0.08
	UB	Helichrysum scorpioides	NA	NA	NA	0.24	0.13	0.22	NA	NA	0.11	0.15	0.10	0.16
	C	Helichrysum scorpioides	NA	NA	NA	0.08	0.08	0.08	NA	NA	0.08	0.15	0.10	0.16
	B	Leptospermum scoparium	0.05	0.25	0.25	0.50	0.90	1.90	0.10	0.10	0.10	0.10	0.20	0.60
	UB	Leptospermum scoparium	NA	NA	NA	0.10	0.20	0.30	NA	NA	5.30	5.50	5.50	5.20
	C	Leptospermum scoparium	NA	NA	NA	1.30	1.30	1.30	NA	NA	8.50	9.90	9.60	9.25
	B	Lissanthe strigosa	0.01	*0.08	0.08	0.12	0.21	0.50	-	-	-	-	-	-
	UB	Lissanthe strigosa	NA	NA	NA	3.70	3.70	3.71	NA	NA	-	-	-	-
	C	Lissanthe strigosa	NA	NA	NA	2.24	2.10	2.24	NA	NA	-	-	-	-
2(iv)	B	Diplarrena moraea	0.11	0.11	0.12	0.12	0.10	0.16	0.21	0.28	0.42	0.41	0.49	0.70
	UB	Diplarrena moraea	NA	NA	NA	0.20	0.20	0.25	NA	NA	0.71	0.86	0.94	1.23
	C	Diplarrena moraea	NA	NA	NA	0.63	0.63	0.91	NA	NA	19.00	21.60	22.60	22.80
	B	Lepidosperma laterale	-	-	-	-	-	-	0.10	0.10	0.20	0.20	0.40	0.60
	UB	Lepidosperma laterale	NA	NA	NA	-	-	-	NA	NA	3.80	4.20	4.75	5.30
	C	Lepidosperma laterale	NA	NA	NA	3.10	3.10	3.30	NA	NA	-	-	-	-
	B	Festuca asperula	0.04	0.05	0.06	0.10	0.16	0.31	-	0.10	0.20	0.30	0.60	0.90
	UB	Festuca asperula	NA	NA	NA	0.14	0.13	0.25	NA	NA	0.26	0.36	0.61	0.78
	C	Festuca asperula	NA	NA	NA	0.24	0.30	0.32	NA	NA	0.09	0.18	0.26	0.32
3(i)	B	Microlaena stipoides	0.14	0.22	0.34	0.46	0.36	0.66	0.03	0.07	0.07	0.12	0.41	0.71
	UB	Microlaena stipoides	NA	NA	NA	0.20	0.19	0.28	NA	NA	0.12	0.10	0.12	0.43
	C	Microlaena stipoides	NA	NA	NA	0.15	0.20	0.21	NA	NA	0.22	0.31	0.31	0.41

APPENDIX 3 CONT.

Group	Treatment /control	Species	Mean percentage cover - type P						Mean percentage cover - type O					
			Time since slash-burn (months)											
			1	2	4	8	16/17	24	1	2	4	8	16/17	24
3(i) cont.	B	Bossiaea prostrata	0.11	0.21	0.14	0.21	0.18	0.36	-	-	-	-	-	-
	UB	Bossiaea prostrata	NA	NA	NA	0.83	0.83	1.02	NA	NA	-	-	-	-
	C	Bossiaea prostrata	NA	NA	NA	0.54	0.53	0.96	NA	NA	-	-	-	-
3(ii)	B	Goodenia lanata	0.13	0.14	0.19	0.19	0.17	0.31	0.02	0.11	0.13	0.10	0.08	0.11
	UB	Goodenia lanata	NA	NA	NA	0.10	0.06	0.09	NA	NA	0.11	0.08	0.06	0.11
	C	Goodenia lanata	NA	NA	NA	0.13	0.13	0.17	NA	NA	0.08	0.08	0.08	0.07
	B	Opercularia varia	0.01	0.03	0.15	0.09	0.13	0.16	0.01	0.13	0.26	0.22	0.25	0.29
	UB	Opercularia varia	NA	NA	NA	0.01	0.01	-	NA	NA	0.03	0.04	0.03	0.01
	C	Opercularia varia	NA	NA	NA	0.06	0.05	0.06	NA	NA	0.01	0.08	0.04	0.08
3(iii)	B	Eucalyptus amygdalina	-	0.01	0.01	-	0.01	0.02	-	-	-	-	-	-
	UB	Eucalyptus amygdalina	NA	NA	NA	0.65	0.64	1.53	NA	NA	0.08	0.03	0.23	0.86
	C	Eucalyptus amygdalina	NA	NA	NA	0.03	0.03	0.03	NA	NA	-	-	-	-
4(i)	B	Acaena novae-zelandiae	-	-	-	0.01	0.04	0.16	-	-	0.01	0.01	0.03	0.14
	UB	Acaena novae-zelandiae	NA	NA	NA	-	-	-	NA	NA	0.01	0.02	0.02	0.04
	C	Acaena novae-zelandiae	NA	NA	NA	-	-	-	NA	NA	0.07	0.06	0.05	0.06
	B	Leontodon leysseri	-	-	0.01	0.01	0.03	0.09	-	-	-	-	0.01	0.04
	UB	Leontodon leysseri	NA	NA	NA	0.01	0.01	0.01	NA	NA	-	-	0.01	0.01
	C	Leontodon leysseri	NA	NA	NA	0.01	0.02	0.01	NA	NA	0.01	0.01	0.01	0.01
	B	Olearia sp.	-	-	0.01	0.03	0.09	0.26	-	-	0.01	0,02	0.02	0.06
	UB	Olearia sp.	NA	NA	NA	0.01	0.01	0.02	NA	NA	0.01	0.01	0.04	0.32
	C	Olearia sp.	NA	NA	NA	-	-	-	NA	NA	0.02	0.05	0.06	0.07
	B	Eucalyptus pulchella	-	-	-	-	0.55	0.47	-	-	-	-	-	0.03
	UB	Eucalyptus pulchella	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Eucalypus pulchella	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
4(ii)	B	Olearia ramulosa	-	-	-	0.01	0.02	0.03	-	-	-	0.01	0.02	0.04
	UB	Olearia ramulosa	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Olearia ramulosa	NA	NA	NA	-	-	0.01	NA	NA	-	-	-	-
	B	Sonchus asper	-	-	-	-	-	-	-	-	0.01	0.01	0.02	0.04
	UB	Sonchus asper	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Sonchus asper	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	B	Helichrysum dealbatum	-	-	-	0.04	0.02	0.05	-	-	-	-	-	0.02
	UB	Helichrysum dealbatum	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Helichrysum dealbatum	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
4(iii)	B	Oxalis corniculata	-	-	-	-	0.01	0.01	-	-	-	-	-	0.01
	UB	Oxalis corniculata	NA	NA	NA	0.03	0.03	0.02	NA	NA	-	-	-	-
	C	Oxalis corniculata	NA	NA	NA	0.03	0.04	0.02	NA	NA	-	-	0.01	0.01
4(iv)	B	Epilobium sarmentaceum	-	-	-	0.01	0.05	0.10	-	-	-	0.01	0.05	0.16
	UB	Epilobium sarmentaceum	NA	NA	NA	-	-	-	NA	NA	-	-	-	0.03
	C	Epilobium sarmentaceum	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
4(v)	B	Helichrysum thyrsoideum	-	-	-	0.01	0.03	0.15	-	-	-	-	0.10	0.40
	UB	Helichrysum thyrsoideum	NA	NA	NA	-	-	-	NA	NA	0.10	0.10	0.20	0.40
	C	Helichrysum thyrsoideum	NA	NA	NA	-	-	-	NA	NA	4.70	4.50	3.90	3,20

APPENDIX 3 CONT.

Group	Treatment /control	Species	Mean percentage cover - type P						Mean percentage cover - type U					
			Time since slash-burn (months)											
			1	2	4	8	16/17	24	1	2	4	8	16/17	24
4(vi)	B	*Astroloma humifusum*	-	-	-	-	0.02	0.02	-	-	-	-	-	0.01
	UB	*Astroloma humifusum*	NA	NA	NA	0.18	0.18	0.22	NA	NA	0.13	0.13	0.13	0.12
	C	*Astroloma humifusum*	NA	NA	NA	0.52	0.53	0.59	NA	NA	0.33	0.33	0.32	0.30
	B	*Cyathodes glauca*	-	-	-	-	-	-	-	-	0.01	0.02	0.03	0.03
	UB	*Cyathodes glauca*	NA	NA	NA	-	-	-	NA	NA	0.55	0.42	0.42	0.43
	C	*Cyathodes glauca*	NA	NA	NA	-	-	-	NA	NA	0.09	0.08	0.07	0.08
	B	*Epacris impressa*	-	-	-	-	-	-	-	-	-	-	0.10	0.10
	UB	*Epacris impressa*	NA	NA	-	-	-	-	NA	NA	1.30	1.30	1.30	1.30
	C	*Epacris impressa*	NA	NA	-	-	-	-	NA	NA	3.60	3.60	3.50	3.60
	B	*Pratia pedunculata*	-	-	-	-	-	-	-	-	-	-	-	0.04
	UB	*Pratia pedunculata*	NA	NA	NA	-	-	-	NA	NA	0.01	0.01	0.01	-
	C	*Pratia pedunculata*	NA	NA	NA	-	-	-	NA	NA	-	0.01	-	-
5(i)	B	*Arthropodium milleflorum*	0.09	0.09	0.10	0.10	0.11	0.09	0.11	0.12	0.14	0.18	0.15	0.09
	UB	*Arthropodium milleflorum*	NA	NA	NA	0.04	0.04	0.04	NA	NA	0.05	0.06	0.06	0.13
	C	*Arthropodium milleflorum*	NA	NA	NA	0.07	0.10	0.10	NA	NA	0.01	0.03	0.05	0.11
	B	*Carex breviculmis*	0.06	0.10	0.11	0.11	0.10	0.11	-	-	-	-	-	0.01
	UB	*Carex breviculmis*	NA	NA	NA	0.05	0.06	0.10	NA	NA	-	-	-	-
	C	*Carex breviculmis*	NA	NA	NA	0.06	0.06	0.10	NA	NA	-	-	-	-
	B	*Dianella tasmanica*	-	-	-	-	-	-	0.01	0.01	0.01	0.01	-	-
	UB	*Dianella tasmanica*	NA	NA	NA	-	-	0.01	NA	NA	0.06	0.12	0.10	0.12
	C	*Dianella tasmanica*	NA	NA	NA	0.01	-	-	NA	NA	-	-	-	-
	B	*Galium albescens* & *G. australe*	0.01	0.02	0.02	0.09	0.09	0.06	-	-	-	-	-	0.01
	UB	*Galium albescens* & *G. australe*	NA	NA	NA	0.02	0.02	-	-	-	-	0.01	0.01	0.01
	C	*Galium albescens* & *G. australe*	NA	NA	NA	-	-	-	-	-	-	0.01	0.01	0.01
	B	*Hypericum gramineum*	0.09	0.11	0.11	0.09	0.10	0.08	0.04	0.05	0.05	0.05	0.05	0.05
	UB	*Hypericum gramineum*	NA	NA	NA	0.16	0.15	0.13	NA	NA	0.07	0.08	0.07	0.07
	C	*Hypericum gramineum*	NA	NA	NA	0.13	0.15	0.13	NA	NA	0.09	0.07	0.08	0.12
	B	*Lagenophora stipitata*	0.03	0.03	0.04	0.07	0.05	0.05	0.01	0.02	0.03	0.02	0.02	0.02
	UB	*Lagenophora stipitata*	NA	NA	NA	0.11	0.09	0.16	NA	NA	0.02	0.07	0.06	0.07
	C	*Lagenophora stipitata*	NA	NA	NA	0.09	0.10	0.09	NA	NA	0.11	0.13	0.16	0.18
	B	*Olearia erubescens*	0.01	0.01	0.03	0.04	0.04	0.04	-	-	-	-	0.01	0.01
	UB	*Olearia erubescens*	NA	NA	NA	0.03	0.04	0.04	NA	NA	-	-	-	-
	C	*Olearia erubescens*	NA	NA	NA	0.02	0.04	0.04	NA	NA	-	-	-	-
	B	*Pimelea humilis*	0.01	0.03	0.04	0.03	0.03	0.05	-	-	-	-	-	-
	UB	*Pimelea humilis*	NA	NA	NA	0.02	0.03	0.05	NA	NA	-	-	-	-
	C	*Pimelea humilis*	NA	NA	NA	0.02	0.02	0.02	NA	NA	-	-	-	-
	B	*Stylidium graminifolium*	0.02	0.02	0.02	0.02	0.01	-	-	-	-	-	-	-
	UB	*Stylidium graminifolium*	NA	NA	NA	0.10	0.08	0.08	NA	NA	NA	-	-	-
	C	*Stylidium graminifolium*	NA	NA	NA	0.01	0.01	0.03	NA	NA	NA	0.01	0.01	0.03
	B	*Wahlenbergia* spp.	0.12	0.13	0.13	0.19	0.22	0.16	0.04	0.08	0.07	0.08	0.07	0.08
	UB	*Wahlenbergia* spp.	NA	NA	NA	0.15	0.13	0.08	NA	NA	0.05	0.06	0.05	0.08
	C	*Wahlenbergia* spp.	NA	NA	NA	0.15	0.15	0.11	NA	NA	0.08	0.09	0.10	0.09
5(ii)	B	*Acacia stricta*	0.10	0.10	0.10	0.10	0.10	0.10	-	0.10	0.10	0.20	0.10	0.10
	UB	*Acacia stricta*	NA	NA	NA	30.60	28.00	27.00	NA	NA	5.50	5.10	4.20	2.00
	C	*Acacia stricta*	NA	NA	NA	7.10	7.10	7.60	NA	NA	5.50	6.00	4.90	5.00

Appendix 3.5

APPENDIX 3 CONT.

Group	Treatment /control	Species	Mean percentage cover - type P						Mean percentage cover - type O					
			Time since slash-burn (months)											
			1	2	4	8	16/17	24	1	2	4	8	16/17	24
5(ii) cont.	B	Pultenaea juniperina	0.03	0.06	0.06	0.06	0.09	0.04	0.10	0.20	0.20	0.20	0.20	0.30
	UB	Pultenaea juniperina	NA	NA	NA	0.73	0.47	0.60	NA	NA	4.50	5.75	7.00	6.25
	C	Pultenaea juniperina	NA	NA	NA	-	-	-	NA	NA	7.30	8.30	7.40	7.30
5(iii)	B	Drosera auriculata	-	-	-	0.03	-	-	-	-	-	0.09	-	0.01
	UB	Drosera auriculata	NA	NA	NA	0.14	0.04	0.02	NA	NA	-	-	-	0.05
	C	Drosera auriculata	NA	NA	NA	0.10	0.02	0.02	NA	NA	-	0.09	0.04	0.05
	B	Orchidaceae spp.	-	0.01	0.03	0.02	0.03	0.01	0.01	0.01	0.05	0.05	0.04	-
	UB	Orchidaceae spp.	NA	NA	NA	0.11	0.13	0.01	NA	NA	0.07	0.08	0.06	0.05
	C	Orchidaceae spp.	NA	NA	NA	0.18	0.17	-	NA	NA	0.03	0.04	0.04	0.02
6(i)	B	Comesperma volubile	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Comesperma volubile	NA	NA	NA	-	-	-	NA	NA	0.01	0.01	-	-
	C	Comesperma volubile	NA	NA	NA	0.01	0.01	0.01	NA	NA	0.01	0.02	0.02	0.01
	B	Dianella revoluta	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Dianella revoluta	NA	NA	NA	-	-	-	NA	NA	-	-	-	0.01
	C	Dianella revoluta	NA	NA	NA	0.05	0.09	0.15	NA	NA	-	-	-	-
	B	Eucalyptus globulus	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Eucalyptus globulus	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Eucalyptus globulus	NA	NA	NA	-	-	-	NA	NA	0.13	0.18	0.13	0.13
	B	Lepidosperma lineare var. inops	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Lepidosperma lineare var. inops	NA	NA	NA	-	-	-	NA	NA	-	-	-	-
	C	Lepidosperma lineare var. inops	NA	NA	NA	0.07	0.08	0.08	NA	NA	-	-	-	-
	B	Leptorhyncos squamatus	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Leptorhyncos squamatus	NA	NA	NA	0.14	0.10	0.10	NA	NA	-	-	-	-
	C	Leptorhyncos squamatus	NA	NA	NA	0.02	0.01	0.02	NA	NA	-	-	-	-
	B	Poranthera microphylla	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Poranthera microphylla	NA	NA	NA	0.01	0.01	-	NA	NA	-	-	0.01	0.01
	C	Poranthera microphylla	NA	NA	NA	0.05	0.04	0.05	NA	NA	0.01	0.02	0.02	0.02
	B	Tetratheca glandulosa	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Tetratheca glandulosa	NA	NA	NA	-	-	-	NA	NA	0.03	0.03	0.03	0.08
	C	Tetratheca glandulosa	NA	NA	NA	-	-	-	NA	NA	0.03	0.03	0.03	0.03
	B	Daviesia ulicifolia	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Daviesia ulicifolia	NA	NA	NA	0.18	0.16	0.10	NA	NA	-	-	-	-
	C	Daviesia ulicifolia	NA	NA	NA	-	-	-	NA	NA	-	-	-	0.01
6(ii)	B	Haloragis teucrioides	-	-	-	-	-	0.01	-	-	-	-	-	0.01
	UB	Haloragis teucrioides	NA	NA	NA	-	-	0.01	NA	NA	-	-	-	-
	C	Haloragis teucrioides	NA	NA	NA	-	-	-	NA	NA	0.24	0.20	0.05	0.05
6(iii)	B	Themeda australis	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Themeda australis	NA	NA	NA	-	0.02	0.02	NA	NA	-	-	-	-
	C	Themeda australis	NA	NA	NA	0.08	0.08	0.16	NA	NA	-	-	-	-
6(iv)	B	Eucalyptus viminalis	-	-	-	-	-	-	-	-	-	-	-	-
	UB	Eucalyptus viminalis	NA	NA	NA	-	-	-	NA	NA	0.06	0.25	0.46	0.42
	C	Eucalyptus viminalis	NA	NA	NA	-	-	-	NA	NA	-	-	-	-

APPENDIX 4.1

Percentage cover of species in fenced and similar unfenced plots assigned to the seven categories of growth response given in Chapter 3.

(A) Type P (B) Type O

F, fenced plot

UF1, UF2, UF3. Unfenced floristically similar subquadrats from the adjacent permanent plot

Percentage cover - type P

(A)

			Time since slash-burn (months)											
			10	← 8 →			← 16/17 →				← 24 →			
Group	Treatment/ Control	Species	F	UF1	UF2	UF3	F	UF1	UF2	UF3	F	UF1	UF2	UF3
1(i)	B	Schoenus apogon	1.1	0.01	0.11	0.09	6.0	0.04	0.45	0.13	13 3	0.37	1.59	0.39
	UB	Oxalis corniculata	0.04	-	0.04	-	0.13	-	0.04	-	0 33	-	-	-
(ii)	B	Pentapogon/Dichelachne	1.21	-	-	-	1.37	-	0.14	-	2.54	-	0.11	-
	UB	Bossiaea prostrata	1.23	0.34	0.18	3.09	1.64	0 28	0.38	2.93	5.44	0.95	0.53	3.31
(iii)	C	Deyeuxia spp.	-	-	0.05	-	0.04	-	-	-	0.06	-	-	-
	C	Stipa pubinodis	-	0.30	-	-	0.19	0.06	-	-	0.43	0.18	-	-
(iv)	B	Eucalyptus viminalis	-	-	-	-	0.65	-	-	-	1.45	-	-	-
	C	Danthonia spp.	-	-	-	-	-	-	-	-	0.05	-	-	-
2(i)	B	Acaena novae-zelandiae	0.38	0.06	-	-	1.98	1.30	-	-	3.43	4.50	-	-
	B	Haloragis tetragyna	0.38	0.26	0.51	0.73	0.55	0.29	0.49	0.46	1.08	0.79	1.39	0.28
	B	Poa spp.	1.48	5.86	5.25	11.21	4 55	7.30	5.98	9.94	7.09	10.55	7.79	12.78
	B	Stipa pubinodis	0.43	0.05	-	-	1.34	0.20	-	-	2.13	1.05	-	-
	C	Bossiaea prostrata	1.35	0.54	0.98	1.04	1.84	0.73	1.01	0.91	3.58	0.89	-	2.49
	C	Pimelea humilis	0.14	0.09	0.02	-	0.19	-	-	-	0.25	0.25	-	-
	C	Lissanthe strigosa	4.62	10.76	8.20	3,13	5.33	9.44	7.40	2.02	6.03	9.79	8.00	2.50
(ii)	B	Leptospermum scoparium	0.13	0.14	-	1.31	0.89	0.13	0.08	2.08	1.81	1.61	0.21	0.86
	B	Senecio minimus	-	0.05	-	-	0.65	1.65	-	-	2.88	5.95	-	-
3(i)	B	Galium albescens & G. australe	0.06	-	0.06	0.01	0.83	-	0.09	0.01	0.07	-	-	0.05
		Lagenophora stipitata	0.03	-	0.04	0.15	0.30	-	-	0.11	0.10	-	-	0.26
		Opercularia varia	0.04	-	-	-	0.33	-	-	-	0.13	0.20	-	-
	UB	Leptorhyncos squamatus	0.05	-	-	0.08	0.56	-	-	0.14	0.11	-	-	0.45
		Microlaena stipoides	0.68	0.35	0.90	-	2.40	0.18	0.30	-	1.88	0.46	1.33	0.49
		Wahlenbergia spp.	0.06	-	0.04	0.07	0.10	-	0.04	0.03	0.05	-	-	-
(ii)	B	Gnaphalium collinum	0.19	0.03	0.17	0.10	0.55	0.08	0.22	0.61	0.36	0.38	0.35	1.16
	UB	Poa labillardiera & P. rodwayi	15.74	10.58	13.33	26.76	22.01	8.12	20.25	36.75	18.34	9.02	25.50	37.14
(iii)	C	Viola hederacea	0.18	0.01	0.94	0.05	0.39	-	0.39	0.08	0.25	-	0.07	-
(iv)														
4(i)	B	Acacia dealbata	0.03	0.20	0.16	0.19	0.10	1.25	0.50	2.38	0.30	3.50	0.38	4.85
		Lomandra longifolia	0.04	21.88	2.69	2.78	0.13	26.40	8.00	10.50	0.18	30.80	8.70	1.00
		Plantago varia	0.49	3.06	0.51	1.08	0.85	1.45	1.88	0.72	1.16	2.58	3.64	1.38
	C	Themeda australis	0.04	-	-	1.54	0.09	-	-	1.45	0.14	-	-	3.54
(ii)	B	Danthonia spp.	0.26	0.74	0.65	-	-	0.84	0.51	-	-	1.94	1.05	-
		Deyeuxia spp.	0.16	0.08	-	-	-	0.22	0.05	-	-	0.10	0.33	-
	UB	Pentapogon/Dichelachne	0.20	0.45	0.13	-	-	0.65	1.26	0.80	-	1.13	2.53	0.70
5(i)	B	Goodenia lanata	0.09	0.61	0.02	-	0.28	0.74	0.06	-	0.30	1.69	0.06	0.03
		Viola hederacea	0.03	0.01	0.38	0.63	0.15	0.07	0.63	0.66	0.10	0.08	0.84	0.66
	UB	Lissanthe strigosa	7.20	10.63	2.41	8.90	9.75	10.63	3.01	8.50	9.56	11.88	3.75	9.90
	C	Astroloma humifusum	4.75	1.88	1.30	-	5.22	1.55	1.30	-	5.97	2.00	1.18	-
		Festuca asperula	-	0.10	-	-	0.15	0.18	-	-	0.13	0.50	-	0.06
		Poa labillardieri & P. rodwayi	28.85	10.66	10.97	13.53	25.65	10.87	18.98	14.80	25.85	11.38	17.42	14.55
(ii)	C	Lepidosperma lineare var. inops	0.15	-	-	0.08	0.20	-	-	0.10	0.20	-	-	0.06
(iii)	UB	Lomandra longifolia	2.81	-	-	-	3.35	-	-	-	3.62	-	-	-
6(i)	UB	Plantago varia	0.50	0.30	0.47	0.20	0.33	0.17	0.61	0.15	0.84	0.54	1.98	-
		Viola hederacea	0.48	0.06	0.02	0.04	0.40	0.03	-	0.02	0.93	0.09	-	0.02
	C	Haloragis tetragyna	0.09	0.05	0.24	0.02	0.04	0.18	0.16	0.06	0.11	0.48	0.11	-
		Hypericum gramineum	0.07	-	0.18	0.11	0.03	-	0.11	0.09	0.18	-	0.01	0.04
(ii)	UB	Schoenus apogon	0.16	-	-	-	0.04	-	-	-	0.15	0.06	-	-
(iii)	B	Bossiaea prostrata	0.05	1.26	0.28	0.15	0.03	0.56	0.17	0.16	0.30	1.46	1.06	0.85
	UB	Haloragis tetragyna	0.11	0.22	1.03	0.38	0.10	0.10	0.76	0.14	0.90	0.59	1.06	0.45
	C	Plantago varia	0.76	0.59	-	0.46	0.46	0.40	-	0.41	1.36	1.01	-	0.31
(iv)														
7	B	Hypericum gramineum	0.01	0.27	0.19	0.24	-	0.08	0.17	0.46	-	0.11	0.19	0.28
	UB	Acacia stricta	37.40	40.93	-	39.07	41.86	40.95	-	38.01	44.11	40.38	-	37.46
		Epacris impressa	0.94	3.85	0.21	4.51	1.48	1.61	0.20	5.43	1.33	1.86	1.38	6.18
		Hypericum gramineum	0.11	0.11	-	0.23	0.10	0.01	-	0.24	0.04	-	-	0.04
		Leptospermum scoparium	1.47	0.23	-	-	1.28	0.33	-	-	1.28	0.33	-	-
	C	Acacia dealbata	5.47	3.67	13.15	2.02	5.07	3.84	11.67	1.96	7.02	3.00	12.73	8.75
		Arthropodium milleflorum	0.08	0.04	0.04	0.13	0.06	-	0.04	0.23	0.04	0.03	-	0.11
		Diplarrena moraea	1.26	0.41	0.01	0.09	1.35	0.26	-	0.09	1.50	0.30	-	0.38
		Lomandra longifolia	17.27	53.76	11.63	-	19.58	54.70	12.17	4.28	19.58	53.20	13.04	1.88
		Orchidaceae spp.	0.06	0.13	0.02	0.61	0.01	0.09	0.03	0.91	-	-	-	-

Appendix 4.2

APPENDIX 4 cont'd.

(b)

Percentage cover - type O

Group	Treatment / Control	Species	Time since slash-burn (months): 10	8			16/17				24			
			F	UF1	UF2	UF3	F	UF1	UF2	UF3	F	UF1	UF2	UF3
1(i)	B	Diplarrena moraea	0.11	0.10	0.13	-	0.48	0.08	0.08	-	0.63	0.08	0.09	-
		Goodenia lanata	0.23	0.13	0.06	-	2.40	0.13	-	-	3.63	0.13	-	-
		Hypochaeris radicata	-	0.50	-	-	0.01	0.40	-	-	0.19	0.42	-	-
		Poa labillardieri	4.01	0.62	0.28	-	9.93	1.51	1.98	-	13.03	2.55	3.89	-
		Pultenaea juniperina	0.14	-	-	-	5.29	-	-	0.02	5.64	-	-	0.04
		Schoenus apogon	0.14	-	-	-	0.25	-	-	-	0.08	0.11	-	-
	C	Microlaena stipoides	0.63	0.58	0.35	1.18	0.88	0.50	0.30	0.91	1.94	0.20	0.16	0.79
(ii)	UB	Danthonia spp.	0.64	-	-	-	1.16	0.58	-	-	2.05	0.66	-	-
(iii)														
(iv)	B	Helichrysum scorpioides	0.38	-	-	-	1.38	-	-	-	2.23	-	-	-
2(i)	B	Viola hederacea	0.81	0.04	0.13	-	1.66	0.69	0.71	-	1.90	1.20	0.68	-
(ii)	B	Microlaena stipoides	0.63	0.56	-	-	0.80	1.20	-	-	1.21	1.49	-	-
3(i)	B	Arthropodium milleflorum	0.68	-	0.06	-	0.98	0.02	0.14	-	0.70	0.05	0.24	-
		Deyeuxia spp.	0.20	0.02	0.01	-	0.80	0.05	0.03	-	0.20	0.09	0.04	-
		Opercularia varia	0.07	0.10	0.02	-	0.13	0.05	0.06	-	0.10	0.04	0.05	-
		Pentapogon/Dichelachne	1.65	-	0.18	-	2.43	-	0.32	-	1.68	0.19	0.49	-
(ii)	B	Hydrocotyle javanica	0.09	0.05	-	-	0.55	0.57	-	-	0.24	0.64	-	-
(iii)	UB	Viola hederacea	1.99	-	0.88	-	2.46	-	2.51	-	1.54	-	0.86	-
(iv)	B	Goodenia ovata	0.05	-	-	-	0.25	-	-	-	-	-	-	-
	UB	Wahlenbergia spp.	0.11	0.03	-	-	1.34	0.01	-	-	0.10	0.01	0.01	-
4(i)	B	Senecio minimus	0.23	0.12	0.38	-	0.56	2.00	4.43	-	0.28	-	15.83	-
	UB	Poa labillardieri	2.93	10.98	9.88	-	4.80	16.80	7.50	-	4.75	17.91	9.27	-
(ii)														
5(i)	UB	Arthropodium milleflorum	0.02	0.15	0.05	-	0.08	0.04	0.01	-	0.08	0.06	0.09	-
		Diplarrena moraea	6.05	1.75	4.50	-	6.81	1.30	4.94	-	6.81	0.68	6.01	-
(ii)														
(iii)														
6(i)														
(ii)	UB	Opercularia varia	0.23	-	-	-	-	-	-	-	-	-	0.02	-
(iii)	C	Pteridium esculentum	15.71	1.36	8.48	6.76	0.68	-	8.87	5.41	14.60	2.58	14.00	18.13
(iv)	UB	Lagenophora stipitata	0.08	0.05	-	-	0.05	-	-	-	0.20	-	-	-
7	UB	Lomandra longifolia	0.94	-	-	-	0.94	-	-	-	1.14	-	-	-
		Lomatia tinctoria.	0.30	-	0.25	-	0.30	-	0.30	-	0.48	-	0.45	-
	C	Acacia stricta	1.27	3.16	-	0.63	1.37	2.92	-	0.63	1.52	3.44	-	0.18
		Coprosma quadrifida	1.30	2.60	-	4.43	1.25	2.67	-	4.50	1.37	4.52	-	4.15
		Danthonia spp.	0.42	0.23	1.60	-	0.46	0.23	0.80	-	0.95	-	1.36	-
		Diplarrena moraea	41.76	11.90	1.52	5.79	42.06	9.56	3.19	6.25	42.36	12.18	0.25	6.50
		Drosera auriculata	-	-	-	0.04	0.01	0.02	-	0.01	-	-	-	-
		Epacris impressa	1.38	2.92	3.23	1.90	2.67	2.86	3.18	1.56	2.87	3.51	3.21	2.01
		Festuca asperula	0.18	0.11	0.55	0.22	0.19	0.25	0.78	0.10	0.15	0.08	0.95	0.44
		Haloragis teucrioides	0.04	0.22	0.12	0.91	0.03	0.04	-	-	0.08	0.13	-	-
		Helichrysum thyrsoideum	5.16	0.07	7.39	27.01	5.32	0.18	4.76	24.34	6.23	0.26	5.86	7.50
		Hypericum gramineum	0.05	-	-	-	0.07	-	-	-	0.08	-	-	-
		Lagenophora stipitata	0.18	0.01	0.19	-	0.21	-	0.11	-	0.30	-	0.26	0.16
		Leptospermum scoparium	3.74	14.68	15.08	3.42	4.89	14.68	15.58	3.47	7.00	16.43	16.38	1.20
		Lomatia tinctoria	5.78	1.98	0.31	1.25	4.71	1.60	-	1.47	4.48	2.18	0.13	1.39
		Pultenaea juniperina	1.52	35.35	16.93	1.58	2.69	34.79	22.30	0.57	2.87	26.40	20.40	0.57
		Viola hederacea	0.06	0.08	0.13	1.11	0.06	0.03	0.13	1.04	0.13	0.28	0.06	0.91

Appendix 5 :

The species of Lepidoptera recorded at MM14 during the summer of 1983/1984.

Family HESPERIIDAE

Subfamily Trapezitinae

Trapezites luteus glaucus Waterhouse and Lyell, 1914

Hesperilla donnysa aurantia Waterhouse, 1927

Family PIERIDAE

Subfamily Pierinae

Pieris rapae rapae (Linnaeus), 1758

Family NYMPHALIDAE

Subfamily Satyrinae

Geitoneura klugii klugii (Guérin-Méneville), 1830

Heteronympha merope (Fabricius), 1775

Oreixenica lathoniella lathoniella (Westwood), 1851

Subfamily Nymphalinae

Vanessa kershawi (McCoy), 1868

Appendix 6 :

The weight (g) of each of the fuel components described in Chapter 4 which were recorded in the individual quadrats sampled at the coupes MM14, MM20, TO2, TO56 and TO30.

Note: the data are presented according to the particular vegetation type (P, O or D/O), the treatment (i.e. slash-burnt and artificially sown (B);or slash left unburnt with natural regeneration (UB)), and the year in which the quadrats were sampled (1982,1983,1984 for MM14; the summer of 1982/1983 for MM20, TO2, TO56 and TO30).

A/GL = elevated live material;
GL = live ground material;
ADV = elevated dead herbaceous vegetation;
ALE = elevated dead leaves;
ALI = elevated exposed lignotuber;
AT1 = elevated dead twigs <0.5 cm diameter;
AT2 = elevated dead twigs 0.5-1.0 cm diameter;
AT3 = elevated dead twigs 1.0-1.5 cm diameter;
AT4 = elevated dead twigs 1.5-2.0 cm diameter;
AB = elevated bark;
AMF = elevated miscellaneous fine material;
AGDT = combined total of elevated dead material;
GDV = dead ground herbaceous vegetation;
GLE = dead ground leaves;
GLI = exposed ground lignotuber;
GT1 = dead ground twigs <0.5 cm diameter;
GT2 = dead ground twigs 0.5-1.0 cm diameter;
GT3 = dead ground twigs 1.0-1.5 cm diameter;
GT4 = dead ground twigs 1.5-2.0 cm diameter;
GB = dead ground bark;
GMF = miscellaneous fine ground material;
GDT = combined total of dead ground material.

MM14: Type P, Treatment B; 1982

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
44.6	41.7	0.2	-	-	37.8	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	17.1	-	-	-	-	-	-	-	-	-
0.1	0.7	-	-	-	-	-	-	-	-	-
7.5	-	2.8	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	1.1	-	-	-	26.3	-	-	-	-	-
-	10.7	-	-	-	1.4	-	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	-
5.0	0.3	5.1	-	-	-	-	-	-	-	-
14.3	15.3	0.6	-	-	0.3	-	-	-	-	-
0.2	-	-	-	-	-	-	-	-	2.9	-
-	4.7	-	-	-	-	-	-	-	427.3	-
-	1.0	-	18.0	-	122.0	-	-	-	-	-
7.4	2.8	-	-	-	-	-	-	-	-	-
2.4	0.9	-	-	-	-	-	-	-	-	-
-	0.4	-	-	-	-	-	-	-	-	-
12.2	2.4	37.6	-	-	-	-	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	-
-	-	-	-	-	6.6	-	-	-	-	-
5.9	2.5	-	-	-	-	2.8	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	-
-	0.3	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	9.2	-

Appendix 6.2

MMI4: Type P, Treatment B; 1982

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
38.0	3.9	5.8	-	53.9	3.4	-	-	11.6	21.6	100.2
-	0.4	11.9	-	23.4	3.7	-	-	2.7	-	42.1
-	7.6	34.7	85.4	101.4	76.3	34.1	-	10.4	7.3	357.2
-	0.2	1.1	-	4.8	3.4	9.7	-	0.5	-	19.7
2.8	1.2	4.3	-	10.2	16.0	9.9	-	0.2	-	41.8
-	-	1.1	-	3.1	-	-	-	2.0	-	6.2
26.3	0.1	3.7	-	12.5	2.8	-	-	-	3.6	22.7
1.4	-	4.7	-	8.1	6.0	-	-	18.3	8.6	45.7
-	-	2.8	-	9.0	8.5	-	54.6	1.6	13.9	90.4
5.1	1.9	0.3	-	13.4	4.6	-	-	0.6	13.7	34.5
0.9	1.3	1.4	105.7	35.3	14.6	23.9	-	3.3	6.3	191.8
2.9	0.2	5.9	105.7	35.3	14.6	23.9	-	3.3	6.3	191.8
427.3	2.2	11.2	20.4	22.5	13.2	-	23.3	60.2	10.6	163.6
140.0	-	10.3	-	12.3	10.3	6.3	-	-	-	39.2
-	1.5	0.6	-	0.4	-	-	-	-	-	2.5
-	-	2.8	-	1.8	3.6	-	-	-	-	8.2
-	-	2.1	-	5.7	11.9	-	25.0	22.8	11.1	78.6
37.6	7.1	13.1	-	10.2	4.4	4.1	-	0.4	3.0	42.3
-	-	-	-	-	-	-	-	-	-	-
6.6	-	16.6	-	6.4	10.5	-	8.2	21.1	15.9	78.7
2.8	3.1	1.7	-	4.5	-	-	-	0.4	-	88.4
-	-	0.2	-	0.1	-	-	-	-	-	0.4
-	2.1	2.7	-	12.2	3.9	-	-	8.1	5.1	34.1
9.2	-	-	-	-	-	-	-	-	-	-

MM14: Type P, Treatment B; 1983

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
23.2	38.5	0.9	-	-	0.2	-	-	-	-	1.1
13.2	29.9	2.4	-	3.9	26.4	0.8	-	-	4.5	0.8
26.7	45.2	0.2	-	-	-	-	-	-	-	-
9.1	12.1	0.1	-	-	-	-	-	-	-	-
6.1	4.0	-	-	-	-	-	-	-	-	-
-	0.7	-	-	-	4.1	-	-	-	-	-
37.8	29.4	4.8	-	-	4.6	-	-	-	-	-
0.4	14.0	0.1	-	-	14.6	-	-	-	-	-
25.2	11.5	0.3	-	-	3.3	6.6	-	-	122.6	-
9.7	50.4	0.5	-	-	-	-	16.1	-	-	-
9.3	32.7	1.0	-	-	3.8	13.4	-	60.6	0.1	-
5.7	3.4	-	-	-	-	-	-	-	-	-
0.3	13.3	0.1	-	-	6.1	53.1	123.3	190.1	55.1	-
11.2	25.3	-	-	-	15.4	40.8	88.9	-	-	-
0.1	17.4	-	-	-	23.3	56.5	12.9	-	1.5	-
3.2	43.1	0.2	-	-	6.1	-	-	19.0	-	-
-	5.4	-	-	-	-	-	-	-	-	-
27.6	14.7	7.6	0.4	-	38.4	-	-	-	-	-
-	2.0	-	-	-	1.8	5.5	-	-	-	-
-	3.1	0.2	-	-	-	34.1	30.1	-	7.3	-
3.1	20.4	0.4	-	-	16.3	-	-	-	-	-
-	2.6	-	-	-	-	-	-	-	-	-
9.4	15.7	0.2	-	-	1.2	-	-	-	-	-
40.5	21.7	-	-	-	-	-	-	-	-	-
1.2	11.1	0.1	-	-	-	-	-	-	-	-

MM14: Type P, Treatment B; 1983

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
2.2	12.5	3.5	-	51.1	48.5	12.8	-	14.5	43.7	186.6
48.8	9.9	26.6	-	34.1	15.8	11.4	-	18.1	-	115.9
0.2	2.3	0.7	-	29.7	44.9	12.7	-	33.2	-	123.9
0.1	1.9	1.4	-	5.8	5.2	-	-	0.4	2.0	16.7
-	2.9	1.9	-	4.2	6.5	-	-	-	-	15.5
4.1	-	-	-	-	-	-	-	-	-	-
9.4	7.9	16.1	-	22.4	10.5	-	-	9.2	5.0	71.1
14.7	0.2	8.3	-	10.9	4.1	50.5	-	21.2	7.5	102.7
132.8	0.4	1.7	-	2.9	1.2	12.5	-	101.2	-	119.9
16.6	0.5	0.7	-	17.3	24.1	64.2	23.5	45.5	10.4	186.2
78.0	6.0	1.8	4.4	10.5	1.4	31.6	-	5.3	-	61.0
-	0.4	2.2	-	3.5	-	-	-	5.5	-	11.6
427.8	1.2	47.9	2.1	39.1	5.3	13.4	28.0	183.1	-	320.1
145.1	0.4	0.3	-	6.5	10.6	-	-	-	-	17.8
94.2	0.1	-	-	3.2	1.1	-	-	0.5	-	4.9
25.3	0.5	2.8	3.5	19.1	22.6	12.7	31.8	32.9	16.2	142.1
-	0.2	0.6	5.2	11.1	7.0	4.4	16.8	9.3	6.2	60.8
46.4	5.8	6.9	-	20.1	4.3	-	-	8.3	9.6	55.0
7.3	0.1	2.5	-	15.3	16.7	-	-	12.2	-	46.8
71.7	2.2	0.5	-	2.0	0.7	-	9.9	0.1	-	15.4
16.7	2.6	3.9	-	4.7	6.2	-	13.0	2.9	8.6	41.9
-	0.2	0.1	-	0.4	-	-	-	-	-	0.7
1.4	0.3	1.7	-	8.5	2.2	9.3	54.3	4.5	-	80.8
-	0.1	6.6	-	2.6	9.4	-	-	109.7	-	128.4
0.1	-	3.1	-	1.9	-	-	-	36.4	-	41.4

Appendix 6.5

MM14: Type P, Treatment B; 1984

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
37.9	15.8	10.7	-	-	-	-	-	-	-	-
48.6	36.3	0.3	0.2	-	6.1	-	-	-	-	-
10.9	34.5	1.2	-	-	-	-	-	-	-	-
84.8	13.4	2.8	0.1	-	-	-	-	-	-	-
37.5	4.2	25.8	-	-	17.2	-	-	-	-	-
0.1	2.6	-	-	-	-	-	-	-	-	-
88.4	11.9	-	-	-	0.6	-	-	-	-	-
11.7	31.8	0.5	-	-	16.2	12.4	-	-	-	-
2.2	2.6	0.3	-	-	0.1	-	-	-	-	-
54.5	55.3	1.0	-	-	-	-	-	-	-	-
22.9	12.0	1.0	-	-	-	-	-	-	-	-
10.7	4.8	0.4	-	-	-	-	-	-	0.1	-
4.1	28.3	0.9	-	-	2.0	28.3	44.1	-	7.0	-
124.3	38.0	0.4	-	-	-	-	-	-	-	-
1.9	41.7	1.4	0.1	-	22.7	22.2	18.5	-	-	-
-	1.8	-	-	-	0.4	-	-	-	2.4	-
-	21.2	-	-	-	-	-	-	-	-	-
0.7	9.4	0.1	-	-	6.1	-	-	-	-	-
43.3	16.3	2.6	-	-	6.7	-	-	-	-	-
0.3	21.5	0.2	-	-	6.1	28.3	-	-	2.7	-
10.6	16.7	0.4	-	-	28.9	33.3	-	-	0.1	-
29.6	32.9	9.4	7.8	-	-	-	-	-	-	-
32.4	15.8	3.0	-	-	-	-	-	-	-	-
0.7	1.1	1.1	-	-	-	-	-	-	-	-
53.2	52.0	0.4	-	-	1.0	2.5	84.2	-	3.1	-

MM14: Type P, Treatment B; 1984

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
10.7	10.9	2.5	-	36.7	9.5	3.1	-	10.1	7.0	79.8
6.6	2.8	34.3	-	33.5	11.6	20.4	97.0	89.1	117.6	406.3
6.6	0.5	0.6	-	24.7	7.9	-	-	18.2	1.9	53.8
2.9	1.4	1.1	-	2.8	-	-	-	-	-	5.3
43.1	18.3	2.6	-	7.2	3.7	-	44.1	-	2.7	78.6
-	-	0.2	-	2.4	5.6	7.8	-	0.2	-	16.2
0.6	0.1	15.1	-	25.1	3.7	81.4	-	15.7	9.1	150.2
29.1	0.7	6.6	-	8.7	15.2	71.3	48.7	8.4	12.5	172.1
0.4	3.4	0.8	-	9.0	8.3	17.6	-	6.5	-	45.6
1.0	6.4	0.5	-	30.4	32.4	21.3	-	13.1	29.6	133.7
1.0	2.5	1.5	22.6	41.4	29.6	9.9	-	7.3	8.4	123.2
0.5	2.1	1.5	-	9.1	0.7	43.1	-	4.8	-	61.3
82.3	3.3	2.2	-	87.3	61.1	17.3	-	243.5	27.4	442.1
0.4	1.0	1.0	-	8.7	6.5	28.8	-	-	-	46.0
64.9	2.4	0.4	-	3.9	1.7	-	-	-	-	8.4
2.8	-	0.5	-	3.6	14.2	-	-	6.7	-	25.0
-	0.2	0.2	-	12.8	6.8	22.5	20.3	11.3	-	74.1
6.2	0.5	2.6	-	11.1	3.1	-	-	3.1	-	20.4
9.3	2.9	2.1	-	20.2	5.8	3.2	-	9.0	3.1	46.3
37.3	4.8	-	-	4.9	6.1	-	-	0.2	-	16.1
62.7	1.2	3.9	-	21.3	4.1	-	-	52.3	4.7	87.5
17.2	9.7	31.1	-	-	-	-	30.6	3.3	-	74.7
3.0	2.8	2.4	-	11.4	2.8	8.5	-	8.4	2.8	39.1
1.1	0.5	0.5	-	6.5	4.9	-	-	28.4	-	40.8
91.2	0.4	5.7	-	4.1	2.4	-	-	2.3	-	14.9

MM14: Type O, Treatment B; 1982

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
0.6	-	-	-	-	-	5.8	-	-	-	-
0.3	1.1	-	-	-	6.4	87.9	-	-	0.3	-
8.2	0.9	-	-	-	0.4	3.5	-	-	0.2	-
-	0.5	-	-	-	7.2	18.1	21.7	-	-	-
5.1	-	-	-	-	-	-	-	-	-	-
34.5	0.1	2.4	-	-	5.3	-	-	-	-	-
7.4	0.8	-	-	-	-	-	-	-	-	-
0.3	0.6	-	-	-	-	-	-	-	-	-
1.4	-	-	-	-	-	-	-	-	-	-
-	7.2	-	-	-	-	-	-	-	-	-
0.5	-	-	-	-	4.8	-	-	-	-	-
32.3	7.7	-	-	-	-	-	-	-	-	-
0.8	0.9	-	-	-	-	4.2	6.2	-	-	-
15.4	-	-	-	-	-	-	-	-	-	-
-	0.6	-	-	-	-	2.8	7.5	-	-	-
0.4	0.8	-	-	-	-	0.6	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	0.5	-	10.1	-	3.6	-	-	-	-	-
-	1.2	-	4.5	-	10.6	23.7	-	-	-	-
10.6	0.8	-	-	-	-	-	-	-	-	-
0.7	0.8	-	-	-	-	-	-	-	-	-
-	0.6	-	-	-	4.5	58.9	98.2	-	-	-
3.6	-	-	3.5	-	4.0	4.2	19.3	-	-	-
1.9	0.2	-	-	-	-	-	-	-	-	-
40.8	0.1	-	-	-	56.8	66.6	24.6	-	-	-

Appendix 6.8

MM14: Type O, Treatment B; 1982

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
5.8	-	1.2	-	-	-	-	-	0.2	-	1.4
94.6	8.9	15.8	-	73.1	9.1	-	-	1.4	10.9	119.2
4.1	0.7	4.9	-	6.1	4.8	6.9	-	0.5	7.7	31.6
47.0	-	0.9	-	1.8	-	-	-	0.4	-	3.1
-	0.6	0.8	19.6	1.8	7.2	-	-	-	-	30.0
7.7	0.1	4.9	-	3.1	2.7	-	32.8	-	-	43.6
-	0.9	0.4	-	-	15.3	-	1.4	-	-	18.0
-	0.7	6.1	-	97.3	8.1	46.9	15.4	2.5	36.3	213.3
-	0.2	15.1	-	3.7	34.6	-	-	0.2	1.4	55.2
-	-	0.5	-	-	-	-	-	0.5	5.9	6.9
4.8	19.3	22.8	-	31.4	12.3	-	-	29.2	28.4	143.9
-	2.2	3.4	-	28.2	2.6	6.6	44.2	9.5	10.6	107.3
10.4	-	0.5	-	-	-	-	-	-	-	0.5
-	7.2	4.6	-	4.6	4.6	23.5	-	5.4	-	49.9
10.3	-	2.3	-	2.7	-	-	-	0.3	-	5.3
0.6	1.8	1.1	-	7.0	-	-	-	0.7	0.3	10.9
-	-	0.2	-	2.9	10.9	-	-	0.5	0.6	15.1
13.7	0.5	14.4	-	3.8	-	-	-	-	-	18.7
38.8	0.4	6.4	-	7.3	2.1	-	-	-	5.4	21.6
-	5.6	8.2	-	25.4	2.6	-	-	0.7	6.6	49.1
-	-	-	-	-	-	-	-	-	-	-
161.6	0.3	3.2	-	1.5	1.8	12.9	-	-	2.3	22.0
31.0	0.3	7.9	-	0.4	-	-	-	25.6	-	34.2
-	-	23.1	-	3.6	11.6	-	-	0.6	3.0	41.9
148.0	4.6	40.5	-	6.7	-	-	10.5	-	-	62.3

MM14: Type O, Treatment B; 1983

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
219.3	185.4	-	-	-	-	-	-	-	-	-
103.3	1.6	39.4	-	-	-	-	-	-	-	-
70.1	5.5	19.0	-	-	-	-	-	-	-	-
47.7	20.1	1.4	-	-	4.7	-	-	-	-	-
104.9	31.8	-	-	-	-	-	-	-	-	-
31.1	27.4	-	-	-	-	-	-	-	-	-
69.6	3.6	9.5	-	-	-	-	-	-	-	-
148.5	133.5	-	-	-	-	-	-	-	-	-
18.0	21.1	11.6	1.1	-	15.5	1.5	18.4	-	-	-
111.0	102.3	1.2	-	-	0.3	-	-	-	-	-
3.7	15.2	-	-	-	8.1	5.4	-	-	-	-
39.7	9.7	0.6	-	-	3.1	3.8	33.7	-	2.1	-
27.9	5.0	-	-	-	-	-	-	-	-	-
2.4	11.8	-	-	-	-	-	-	-	-	-
25.7	4.0	0.5	-	-	-	-	-	-	-	-
32.2	14.2	0.2	-	-	7.3	-	-	-	-	-
12.6	10.3	0.6	-	-	-	-	-	-	-	-
9.5	14.5	-	-	-	-	-	-	-	-	-
2.4	2.5	-	-	-	-	-	-	-	-	-
56.0	37.7	1.6	-	0.7	-	-	-	-	-	-
0.1	8.2	-	-	-	0.8	-	-	-	-	-
135.0	99.9	8.2	-	-	-	-	-	-	-	-
1.3	2.8	-	-	-	-	-	-	-	-	-
2.7	10.6	-	-	-	0.5	-	-	-	-	-
1.6	12.7	-	-	-	-	-	-	-	-	-
7.2	4.2	2.4	-	-	-	1.7	-	-	-	-
58.8	3.3	16.9	-	-	48.4	61.3	145.3	120.5	11.9	-

Appendix 6.10

MM14: Type O, Treatment B; 1983

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
-	30.4	16.8	-	6.2	10.0	4.5	-	0.3	-	68.0
39.4	11.3	3.0	-	5.4	1.0	-	-	-	-	20.7
19.0	35.1	13.1	-	15.4	3.3	31.2	-	7.2	-	105.3
6.1	6.8	7.1	-	-	-	-	-	-	-	13.9
-	1.1	0.4	-	7.6	8.5	-	-	0.2	-	17.8
-	8.0	0.7	30.2	4.3	16.9	2.9	-	1.5	-	64.5
9.5	35.2	3.6	49.3	7.9	1.2	-	-	0.7	2.2	100.1
-	1.3	0.3	-	7.6	12.5	-	-	0.2	-	29.5
48.1	17.0	12.8	-	42.1	22.2	15.6	-	9.1	42.9	161.7
1.5	2.1	25.3	-	2.7	-	-	-	-	-	30.1
13.5	0.2	1.7	-	5.7	5.1	48.2	7.2	0.1	-	68.2
43.3	3.1	8.6	-	18.5	11.4	6.2	10.6	2.8	-	61.2
-	0.8	5.2	-	2.8	0.7	-	20.8	6.1	-	36.4
-	0.4	2.6	-	3.6	-	-	-	3.3	-	9.9
0.5	0.1	-	-	3.7	-	-	-	0.6	-	4.4
7.5	3.8	2.7	-	7.7	23.4	-	-	0.3	-	37.9
0.6	1.6	0.7	-	1.6	-	-	-	0.1	-	4.0
-	2.3	1.0	-	8.0	5.9	-	-	2.5	-	19.7
-	0.1	-	-	1.7	2.1	4.5	36.7	0.8	-	45.9
2.3	6.8	14.2	-	-	-	-	-	0.1	-	21.1
0.8	0.9	7.6	-	8.6	10.5	-	52.7	14.4	-	94.7
8.2	28.3	1.4	-	4.6	-	-	-	-	-	34.3
-	2.7	5.1	-	7.6	31.2	63.6	50.1	18.1	-	178.4
0.5	3.0	-	-	1.8	-	-	-	6.2	-	11.0
-	1.4	2.7	-	3.5	3.3	5.7	-	3.2	-	19.8
4.1	1.1	18.7	-	8.6	3.5	-	-	1.1	-	3.3
404.2	24.1	2.2	-	19.3	2.3	3.1	-	3.3	-	54.3

MM14: Type O, Treatment B; 1984

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
20.8	38.2	1.5	-	-	-	-	-	-	-	-
129.5	16.8	9.7	-	-	-	-	-	-	-	-
82.0	11.4	60.2	-	-	-	-	-	-	-	-
74.8	63.1	1.7	-	-	14.9	38.3	-	-	0.2	-
39.2	38.8	-	-	-	1.8	-	-	-	0.1	-
20.1	8.7	0.3	-	-	-	-	-	-	-	-
76.3	7.7	86.2	-	-	-	-	-	-	-	-
380.4	323.2	3.4	-	-	-	-	-	-	-	-
89.9	46.9	12.8	-	-	-	23.7	-	-	-	-
88.0	24.1	33.8	-	-	0.9	-	-	-	-	-
55.5	11.2	6.0	-	-	-	-	-	-	-	-
61.6	7.1	33.9	0.2	-	3.8	-	-	-	-	-
76.5	6.7	32.7	0.7	-	-	-	-	-	-	-
25.7	5.6	8.5	3.1	-	0.1	-	-	-	-	-
47.1	3.9	74.1	6.6	-	-	-	-	-	-	-
99.2	44.1	0.1	-	-	3.0	68.5	58.2	106.3	0.7	-
24.8	22.5	-	-	-	-	-	-	-	-	-
2.3	24.9	1.5	-	-	-	-	-	-	-	-
-	1.6	2.0	0.3	-	-	-	-	-	-	-
26.3	8.0	0.5	-	-	-	-	-	-	-	-
-	12.2	0.6	-	-	42.0	23.0	37.3	-	0.1	-
35.7	9.8	39.8	-	-	-	-	-	-	-	-
92.3	26.6	20.6	-	-	-	-	-	-	-	-
8.1	10.9	0.2	-	-	-	-	-	-	-	-
11.7	14.4	-	-	-	-	-	-	-	-	-
1.5	10.2	-	-	-	-	-	-	-	-	-
288.8	5.6	116.9	0.2	-	30.7	7.5	-	-	-	-

MM14: Type O, Treatment B; 1984

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
1.5	0.8	0.8	-	12.4	13.4	25.5	24.2	0.1	2.5	79.7
9.7	26.6	5.2	-	13.4	-	-	-	10.2	3.8	59.2
60.2	30.2	5.6	-	55.9	38.9	-	-	1.6	-	132.2
55.1	16.8	11.6	-	11.4	4.6	-	-	-	-	44.4
1.9	0.2	0.5	-	11.5	4.6	-	-	1.1	-	17.9
0.3	-	-	-	180.4	114.2	189.2	154.0	-	-	637.8
86.2	0.3	-	-	1.3	17.9	17.5	-	-	-	37.0
3.4	40.4	0.2	-	-	-	-	-	1.3	-	41.9
36.5	18.5	15.7	-	47.6	28.0	44.5	14.9	7.3	19.1	195.6
34.7	8.0	11.2	-	13.4	4.3	-	-	4.6	-	41.5
6.0	5.4	1.3	-	1.4	3.1	47.7	-	-	-	58.9
37.9	21.0	8.0	-	19.8	23.3	4.1	-	0.3	5.0	81.5
33.4	1.5	8.9	-	1.7	5.7	-	-	-	-	17.8
11.7	0.4	1.6	-	-	3.8	-	-	-	-	5.8
80.7	16.1	1.5	-	4.3	3.9	18.9	-	4.0	6.1	54.8
236.8	1.2	3.7	-	5.6	6.1	4.2	-	-	-	20.8
-	0.9	-	-	-	-	-	-	-	-	0.9
1.5	0.2	-	-	4.3	3.3	-	10.5	0.2	-	18.5
1.5	0.2	2.0	-	14.4	11.8	5.6	47.2	4.4	2.9	88.5
0.5	2.2	8.1	-	6.6	0.9	15.8	33.7	2.6	-	69.9
103.0	2.7	1.1	-	21.8	18.3	3.1	-	0.9	-	47.9
39.8	11.1	0.1	-	1.3	-	-	-	0.8	-	13.3
20.6	9.2	4.5	-	9.0	5.4	-	-	2.4	-	35.0
0.2	1.5	0.3	-	1.5	-	-	-	1.1	-	4.4
-	1.4	1.6	-	2.6	1.3	-	22.6	-	-	29.5
-	0.2	15.4	-	6.5	-	-	-	2.8	-	24.9
155.3	20.0	1.1	-	9.1	27.8	15.4	-	7.1	-	90.5

MM14: Type P, Treatment UB; 1982

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
109.4	39.7	-	4.4	-	31.7	12.9	12.7	-	1.5	-
29.8	62.5	0.4	13.3	-	49.5	30.4	56.4	-	12.8	-
0.1	7.1	-	-	-	-	-	-	-	-	-
60.3	45.3	1.2	-	-	5.7	-	-	-	-	-
4.2	35.6	-	-	-	-	-	-	-	-	-
1.5	7.3	-	1.4	-	6.7	57.3	142.4	-	-	-
3.1	14.0	-	-	-	-	-	-	-	-	-
31.1	9.4	6.6	-	-	1.2	-	-	-	-	-
11.1	6.5	-	-	-	1.6	-	-	-	-	-
9.1	0.9	-	-	-	9.9	-	-	-	8.0	-
35.6	6.5	8.4	-	-	4.7	-	-	-	-	-
2.0	3.3	-	-	-	-	-	-	-	-	-
29.7	1.3	2.5	-	-	3.4	-	-	56.9	1.6	-
97.1	13.4	0.2	-	-	0.8	-	-	-	4.9	-
0.2	6.8	-	-	-	6.1	29.1	-	-	6.3	-
61.8	30.6	10.3	14.8	-	93.8	22.3	76.2	96.8	4.3	-
31.2	4.2	-	-	-	6.6	10.7	-	-	-	-
159.8	16.9	2.5	-	-	-	-	-	-	-	-
19.1	30.1	-	-	-	0.9	23.9	-	-	-	-
9.3	25.4	0.1	0.2	-	4.7	3.8	-	-	-	-
2.3	31.0	-	-	-	0.6	-	-	-	-	-
-	1.1	-	-	-	-	-	-	-	-	-
16.9	5.1	0.7	-	-	-	-	-	-	-	-
34.1	3.2	-	-	-	-	-	-	-	-	-

MM14: Type P, Treatment UB; 1982

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
63.2	6.1	56.3	-	102.8	30.7	63.9	-	39.0	28.1	326.9
162.8	11.1	63.2	-	57.2	14.5	-	-	6.8	4.9	157.0
-	0.5	23.6	-	58.1	24.7	7.8	-	56.1	49.7	220.5
6.9	-	0.4	-	30.8	57.9	50.0	8.7	13.3	33.9	195.0
-	9.2	10.4	-	5.3	7.3	-	-	0.6	5.8	38.6
207.8	1.1	52.3	-	126.4	23.8	118.2	-	25.8	9.2	356.8
-	0.6	-	-	23.7	3.7	-	-	6.8	7.3	42.1
7.8	10.3	19.6	-	15.6	-	-	-	3.2	16.6	65.3
1.6	11.3	1.7	-	69.9	18.0	30.7	41.4	94.6	54.5	322.1
17.9	1.2	33.0	-	88.8	6.7	14.2	7.0	47.6	18.2	216.7
13.1	24.8	28.9	-	18.5	2.8	-	-	11.4	22.0	108.4
-	0.5	118.0	31.2	13.6	27.4	-	-	-	36.7	227.4
64.4	2.4	81.7	-	43.5	7.2	25.8	-	80.6	159.2	400.4
5.9	7.4	36.3	-	32.3	19.6	15.2	-	10.4	17.4	138.6
41.6	-	77.6	-	109.1	99.3	44.0	41.3	265.1	28.2	664.6
318.5	54.4	18.5	-	27.6	8.6	-	-	7.1	13.9	130.1
17.3	9.3	57.2	-	64.3	28.3	5.9	56.2	93.2	39.4	358.8
2.5	-	19.9	-	8.1	10.4	39.3	-	63.6	9.4	150.7
24.8	46.3	31.6	-	34.5	37.6	34.5	-	31.1	31.4	444.0
8.8	14.9	5.6	-	42.6	6.8	-	-	19.4	17.1	106.4
0.6	0.2	1.2	-	36.4	15.7	34.7	6.4	20.2	12.7	127.5
-	6.3	8.8	-	9.1	-	-	-	5.4	-	29.6
0.7	1.2	29.1	-	33.3	19.6	-	-	31.1	37.3	151.6
-	-	16.7	-	58.1	14.8	27.7	-	22.8	26.2	166.3

MM14: Type P, Treatment UB; 1983

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
37.6	15.4	1.6	-	-	7.7	32.2	31.1	121.8	13.4	-
163.5	57.2	0.2	0.1	-	25.6	32.7	71.9	-	14.0	1.4
2.6	24.1	0.2	0.1	-	3.1	-	-	-	384.6	-
152.7	50.3	9.6	-	-	-	-	-	-	-	-
4.7	27.8	0.4	-	-	-	-	-	-	-	-
60.5	15.7	0.1	132.8	-	167.7	29.0	-	-	-	-
33.0	30.7	0.4	-	-	-	-	-	-	-	-
22.7	3.4	0.5	-	-	-	-	-	-	-	-
3.7	14.0	0.2	-	-	-	-	-	-	-	-
10.8	51.4	-	-	-	52.8	-	-	-	-	-
80.6	35.5	9.3	-	-	-	-	-	-	-	-
52.1	23.0	4.5	3.1	-	9.0	-	-	-	-	-
7.1	3.6	-	0.2	-	-	-	-	-	1.5	-
0.2	2.7	-	-	-	0.4	-	-	-	-	-
72.3	16.5	0.1	1.3	-	19.6	51.5	83.1	-	52.8	-
7.6	54.4	-	-	-	5.2	10.0	15.9	-	0.1	-
416.8	57.3	19.2	16.4	-	13.0	-	-	-	0.6	-
245.3	10.0	4.2	-	-	23.9	44.7	24.7	-	120.9	-
-	45.3	0.2	8.0	-	43.7	67.2	157.3	72.9	378.3	-
1.7	12.5	-	-	-	8.4	30.1	-	-	-	-
41.6	50.8	0.3	3.6	-	11.1	3.2	-	-	49.8	-
4.0	18.6	0.5	-	-	0.8	-	-	-	1.1	-
52.6	4.4	0.1	-	-	0.2	16.6	-	-	1.3	-
22.6	4.0	0.2	-	-	-	-	-	-	-	-
36.3	13.5	0.2	0.1	-	-	-	-	-	-	-
1.2	2.0	-	-	-	-	-	-	-	-	-

MM14: Type P, Treatment UB; 1983

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
207.8	8.5	83.1	-	112.6	68.8	40.1	-	55.0	31.7	399.8
145.9	10.4	109.9	-	50.3	51.0	10.5	-	5.5	7.7	245.3
388.0	1.9	2.1	-	13.2	15.5	51.2	94.8	55.4	9.5	243.6
9.6	76.7	132.8	-	49.0	27.1	10.1	-	11.4	52.4	359.5
0.4	2.4	1.4	-	4.7	0.8	3.6	-	2.1	-	15.0
329.6	75.2	160.6	-	219.3	65.1	66.1	-	6.9	2.2	595.4
0.4	12.9	7.1	-	11.2	3.5	2.9	-	2.3	18.0	57.9
0.5	5.1	5.4	13.0	14.7	5.6	15.4	-	9.3	17.6	86.1
0.2	4.2	2.2	-	18.6	1.9	3.8	9.4	46.6	-	86.7
52.8	4.7	9.6	-	33.6	13.3	-	-	6.1	23.1	90.4
9.3	66.2	50.9	-	47.4	-	-	-	119.2	53.5	337.2
16.6	48.5	67.7	-	69.8	38.7	28.1	-	19.9	36.4	309.1
1.7	1.6	94.9	-	40.6	18.7	-	-	39.8	43.4	239.0
0.4	0.6	40.4	-	39.0	4.9	-	-	11.6	4.4	100.9
208.4	0.4	32.8	-	47.6	32.4	3.3	-	36.4	8.7	161.6
31.2	20.6	53.3	-	105.9	100.9	207.0	-	49.2	53.4	590.3
49.2	47.8	37.7	-	27.9	10.1	69.9	39.5	23.1	21.3	277.3
218.4	20.3	107.0	-	46.2	61.2	2.4	-	105.7	15.5	358.3
727.6	3.5	41.5	-	24.7	7.3	22.4	-	92.8	12.4	204.6
38.5	0.7	34.8	-	35.3	39.4	65.2	-	74.0	32.1	281.5
68.0	20.1	1.9	-	29.1	23.7	48.5	-	76.3	28.8	228.4
2.4	0.1	0.2	-	8.2	21.4	13.9	-	2.4	1.4	47.6
18.2	-	28.9	-	18.4	30.3	29.5	-	9.1	18.1	134.5
0.2	3.5	3.4	-	15.2	8.8	4.5	-	11.8	9.2	56.4
0.3	10.7	9.5	-	41.4	6.6	3.6	51.9	11.7	14.7	98.2
-	0.5	-	3.7	-	-	-	-	-	-	4.2

MM14: Type P, Treatment UB; 1984

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
182.0	14.5	2.9	-	-	8.8	39.2	-	-	14.0	-
31.2	53.3	2.9	-	-	23.4	1.7	-	-	8.9	-
8.1	37.1	0.8	-	-	-	-	-	-	-	-
44.5	119.0	9.3	-	-	0.2	-	-	-	-	-
101.2	37.6	0.1	-	-	-	-	-	-	-	-
16.0	16.1	0.2	0.1	-	7.2	-	-	-	148.9	-
83.6	62.1	56.1	0.7	-	0.2	-	-	-	0.3	-
49.8	17.8	51.6	0.2	-	-	-	-	-	-	-
32.0	22.6	3.2	-	-	-	-	-	-	-	-
16.6	17.2	-	0.3	-	6.8	20.6	12.2	-	2.9	-
1.2	27.4	1.6	0.1	-	5.6	-	-	-	-	-
11.5	11.6	0.6	-	-	3.4	7.1	-	-	0.1	-
20.6	3.7	-	-	-	-	-	-	-	5.1	-
87.8	4.2	26.1	-	-	2.4	-	-	-	-	-
19.3	204.2	4.5	-	-	0.5	-	-	-	-	-
-	8.8	0.2	-	-	-	4.4	-	-	0.1	-
20.5	27.6	0.6	-	-	-	-	-	-	-	-
38.7	29.3	9.0	-	-	7.8	-	-	-	1.5	-
17.8	33.9	2.1	-	-	7.2	14.6	42.2	97.9	8.3	-
5.3	4.4	0.2	-	-	0.1	-	-	-	-	-
75.2	434.4	9.4	0.1	-	35.7	58.2	109.9	-	24.9	-
10.9	28.2	2.5	-	-	-	-	-	-	-	-
101.5	125.9	42.6	-	-	5.7	5.0	-	-	-	-
44.4	34.0	0.3	-	-	13.6	9.5	28.7	-	0.9	-
26.4	20.1	3.2	-	-	-	-	-	-	-	-
2.2	16.0	-	-	-	-	-	-	-	-	-

MM14: Type P, Treatment UB; 1984

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
64.9	7.4	11.8	-	56.3	19.5	8.1	-	64.5	58.6	226.2
36.9	14.7	2.7	-	33.0	74.9	41.4	40.0	10.9	23.7	241.3
0.8	5.4	1.2	14.7	16.9	3.7	-	2.6	2.2	7.4	54.1
9.5	217.0	0.2	-	8.4	-	40.8	-	19.2	8.8	294.4
0.1	7.3	1.1	-	6.5	3.7	3.4	-	2.4	2.4	26.8
156.4	10.0	6.2	-	77.2	9.6	40.8	-	34.6	9.8	188.2
57.3	176.2	15.0	-	-	28.3	12.4	-	5.8	19.2	256.9
51.8	53.8	1.3	-	8.2	7.5	6.7	-	0.2	1.7	79.4
3.2	4.1	2.3	-	34.6	27.2	14.6	-	25.7	10.2	118.7
42.8	1.6	6.8	-	63.3	163.6	64.9	-	28.8	37.3	366.3
7.3	2.5	2.7	-	15.2	20.9	18.4	11.4	5.9	5.7	82.7
11.2	13.3	38.8	-	36.2	30.6	31.2	-	19.7	22.1	191.9
5.1	1.9	75.9	-	41.1	54.4	10.1	-	61.2	46.6	291.2
28.5	12.3	13.7	-	17.7	10.2	27.2	-	6.2	16.0	103.3
5.0	0.7	15.5	-	26.9	12.1	35.8	-	15.7	19.0	125.7
4.7	2.4	5.3	-	21.7	19.5	8.4	-	50.3	2.7	110.3
0.6	11.9	8.0	-	14.1	10.9	10.4	-	5.5	9.6	70.4
18.3	48.0	35.7	-	32.1	28.8	-	-	27.1	31.6	203.3
172.3	32.4	2.6	-	19.3	13.5	22.7	-	42.6	21.4	154.5
0.3	0.8	44.5	-	16.9	6.8	-	-	9.2	-	78.2
238.2	28.5	7.2	-	60.4	52.0	143.0	-	25.8	39.2	356.1
2.5	19.8	0.1	1.6	1.8	6.4	6.6	-	0.6	-	36.9
53.3	162.9	7.1	-	16.0	17.9	1.6	-	9.6	14.9	230.0
53.0	8.0	36.8	-	42.1	64.1	48.0	122.2	8.6	65.4	395.2
3.2	5.9	10.5	-	31.1	29.3	33.8	63.8	3.0	17.8	195.2
-	0.5	3.9	-	7.2	-	-	-	4.5	-	16.1

MM14: Type O, Treatment UB; 1982

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
-	5.2	-	26.4	-	147.5	84.7	50.9	-	-	-
30.1	36.8	1.2	9.1	-	10.6	-	-	-	0.9	-
104.1	10.8	27.3	31.1	55.7	14.7	-	10.0	105.0	9.0	1.5
4.7	12.5	8.2	-	-	13.4	9.7	-	-	-	-
128.4	1.6	38.9	-	-	-	-	-	-	-	-
13.2	58.4	2.4	3.7	-	24.8	32.4	40.4	-	7.8	-
206.1	23.6	4.4	0.2	-	4.4	2.4	3.0	-	0.2	-
12.2	8.2	8.5	-	-	7.6	15.5	69.8	-	-	-
34.2	29.2	0.3	8.2	-	6.4	52.3	19.8	-	25.5	-
18.4	9.9	3.7	-	-	-	-	-	-	-	-
-	4.8	-	-	-	-	-	-	-	-	-
90.5	10.8	33.8	5.6	-	2.6	-	-	-	-	-
118.7	18.0	-	-	-	16.0	-	-	-	-	-
68.5	1.6	-	7.7	-	39.7	20.5	-	-	11.2	-
8.9	46.5	-	-	-	-	-	-	-	371.5	-
2.7	21.7	-	66.0	-	27.3	-	-	-	1.6	-
47.6	16.0	0.2	61.2	-	29.1	24.9	-	42.7	0.4	-
50.3	1.3	-	-	-	-	-	-	-	-	-
6.6	-	5.6	0.3	-	-	3.4	-	-	8.3	-
10.1	22.3	-	-	-	0.6	-	-	-	-	-

Appendix 6.20

MM14: Type O, Treatment UB; 1982

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
309.5	1.6	54.9	-	78.3	7.4	99.6	18.1	24.1	0.9	284.9
21.8	44.7	111.5	-	59.6	9.4	38.2	11.3	38.6	44.4	357.7
254.3	44.9	149.2	-	85.5	20.0	97.5	26.4	109.8	42.4	575.7
31.4	8.5	1.2	-	2.1	-	-	-	-	-	11.9
38.9	75.9	41.4	-	52.7	-	-	53.8	17.4	-	241.2
111.5	58.5	41.2	-	536.8	84.8	45.5	114.3	35.0	-	916.1
14.6	11.6	15.1	-	29.3	-	-	-	6.3	11.4	73.7
101.4	5.8	82.7	-	134.2	69.2	66.8	18.7	116.4	50.4	544.2
112.5	9.4	150.0	-	123.1	47.1	31.9	88.2	-	25.3	475.0
3.7	14.4	34.7	-	39.4	17.1	-	-	5.9	34.2	145.7
-	14.1	0.4	-	21.5	18.4	9.4	18.5	81.5	28.0	191.8
42.0	7.0	24.3	-	34.2	16.8	5.5	-	17.7	32.6	138.1
16.0	7.2	6.8	-	45.3	16.7	9.2	-	10.6	10.1	105.9
79.1	6.5	107.1	-	129.1	138.1	77.0	96.8	14.8	31.9	601.3
371.5	109.0	10.4	-	81.9	26.1	70.8	64.1	25.7	93.6	481.6
94.9	33.3	256.2	-	156.8	36.0	14.3	75.1	25.6	39.1	636.4
158.5	9.6	56.0	-	77.4	27.9	41.1	-	31.2	66.5	309.7
-	48.2	6.4	-	31.2	32.2	15.3	-	7.2	-	140.5
17.6	5.9	22.1	-	1172.1	47.2	-	-	32.2	-	1279.5
0.6	56.7	7.4	-	36.1	17.1	-	-	2.1	11.0	130.4

MM14: Type O, Treatment UB; 1983

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
16.2	5.1	5.3	1.2	-	36.2	41.6	40.9	-	0.8	-
9.1	2.1	0.6	-	-	-	-	-	-	-	-
11.3	4.3	1.2	-	-	0.4	17.9	-	-	3.7	-
38.4	7.3	-	53.6	-	124.1	109.5	13.3	104.1	134.8	2.5
25.9	12.2	1.3	-	-	2.6	-	-	-	-	-
31.8	15.5	0.9	-	-	5.7	-	-	-	-	-
17.0	32.3	16.2	0.1	-	27.5	1.6	-	-	7.3	-
38.0	22.5	0.2	-	-	5.3	-	-	-	16.9	-
60.1	75.6	1.7	-	-	-	-	-	-	-	-
163.2	58.4	42.7	0.9	-	0.3	-	-	-	-	-
3.9	2.0	0.2	8.4	-	11.3	56.8	-	-	45.0	-
161.1	18.3	3.3	6.1	-	41.8	11.6	40.7	38.9	14.5	-
2.4	2.5	2.3	-	-	-	-	-	-	-	-
1.6	-	0.1	4.3	-	1.1	-	-	-	66.4	-
68.9	33.4	5.6	-	-	14.6	10.4	-	-	-	-
20.2	10.9	37.2	0.2	-	16.5	27.2	10.4	-	5.8	-
4.2	27.6	0.8	0.6	-	35.0	-	-	-	-	-
10.6	10.0	0.1	-	-	-	-	-	-	-	-
59.1	24.6	12.8	0.1	-	0.8	-	-	-	-	-
67.8	21.2	10.8	0.3	-	15.7	9.1	-	-	0.1	-
10.0	31.9	16.9	-	-	0.3	-	-	-	50.9	-
24.1	1.2	33.9	-	-	7.2	34.5	88.9	-	13.1	-
0.4	1.0	0.3	5.0	-	175.5	79.4	93.8	21.4	-	-
47.1	46.9	22.1	-	-	0.2	-	-	-	-	-
66.8	21.2	-	-	-	-	-	-	-	-	-

MM14: Type O, Treatment UB; 1983

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
126.0	6.2	25.5	-	50.7	14.1	35.7	-	38.3	1.6	172.1
0.6	5.5	7.1	-	8.9	5.5	6.8	-	1.4	-	35.2
23.2	1.8	64.4	-	112.7	67.9	37.6	23.6	100.9	19.7	428.6
541.9	23.4	116.1	-	91.1	11.6	-	-	136.7	9.9	388.8
3.9	8.3	57.3	-	40.1	13.5	17.6	-	9.6	34.1	180.5
6.6	32.3	0.2	-	41.4	11.1	20.1	6.0	57.4	22.3	190.8
52.7	181.3	4.8	-	53.7	45.3	5.3	-	16.6	30.9	337.9
22.4	5.3	2.2	-	38.4	21.1	-	-	33.8	12.1	112.9
1.7	298.9	21.9	-	92.6	49.7	44.3	-	50.6	88.0	646.0
44.8	41.2	14.4	-	24.7	16.8	35.6	-	13.8	20.2	166.7
121.7	0.6	200.3	-	162.2	2.7	20.9	52.3	110.0	80.0	629.0
156.9	14.7	72.7	1.6	48.7	34.1	6.2	50.7	10.3	45.8	284.8
2.3	30.3	0.3	-	21.6	35.3	25.3	-	177.0	-	289.8
71.9	-	2.4	-	175.1	122.2	136.6	149.9	0.7	44.5	481.5
25.5	65.8	3.5	-	5.9	-	-	17.1	1.5	4.5	98.3
97.3	47.4	38.7	-	50.6	20.2	70.3	15.7	10.3	3.2	256.4
36.4	0.6	8.0	-	29.3	16.2	-	-	5.4	6.3	65.8
0.1	1.5	76.0	-	81.7	50.4	12.2	-	26.1	12.1	260.0
13.7	15.5	2.5	-	22.1	18.0	5.8	-	14.7	14.8	93.4
36.8	49.7	26.4	-	30.4	15.6	27.9	-	4.5	22.8	177.3
68.1	6.4	2.8	-	27.2	32.4	35.7	-	12.5	8.0	147.5
177.6	39.1	33.4	-	79.7	46.4	41.7	-	99.1	43.0	382.4
375.4	19.8	259.9	-	479.6	183.2	27.3	-	79.1	33.0	1081.9
22.3	122.9	5.5	-	15.3	15.8	17.2	9.8	6.3	27.3	220.1
-	11.7	1.5	-	9.6	10.2	-	-	0.5	3.8	37.3

MM14: Type O, Treatment UB; 1984

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
5.4	6.4	0.8	4.2	-	17.3	15.9	51.2	141.2	124.3	1.9
0.6	7.5	-	-	-	-	-	-	-	0.1	-
85.9	40.5	8.3	10.5	-	53.1	57.0	-	106.5	18.8	-
169.5	85.2	1.1	1.7	-	2.7	-	-	-	-	-
20.4	8.5	7.0	-	-	-	-	-	-	-	-
44.9	32.4	1.3	-	-	1.8	-	-	-	-	-
16.3	76.5	5.6	-	-	25.4	24.3	-	-	-	-
43.4	22.9	57.9	-	-	-	-	-	-	-	-
119.3	91.4	38.0	1.5	-	35.3	35.1	47.6	-	95.2	-
721.6	346.1	91.4	0.6	-	9.0	6.9	10.7	-	-	-
45.4	44.1	0.5	-	-	3.5	-	-	-	-	-
164.8	15.8	6.4	6.7	-	38.0	41.2	43.4	-	0.6	-
54.1	23.1	4.5	-	-	-	-	-	-	-	-
42.7	75.1	7.3	-	-	0.8	9.0	12.5	-	-	-
-	0.7	-	-	-	-	-	-	-	-	-
5.8	13.4	0.4	-	-	6.8	14.4	2.2	-	-	-
18.0	0.3	-	1.6	-	13.6	9.3	-	-	-	-
17.9	15.9	0.1	-	-	-	-	-	-	-	-
14.7	15.9	0.2	-	-	0.1	-	-	-	-	-
63.8	52.6	12.6	0.2	-	-	-	-	-	-	-
30.1	19.0	3.4	-	-	-	-	18.6	55.5	7.4	-
8.4	1.2	-	0.2	-	28.4	35.5	9.7	123.1	18.7	-
94.2	64.1	13.2	0.4	-	7.9	5.7	9.6	15.1	22.2	-
91.1	52.1	20.0	0.5	-	2.2	-	-	-	-	-
120.7	36.2	32.0	-	-	-	-	-	-	-	-

Appendix 6.24

MM14: Type O, Treatment UB; 1984

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
356.8	5.5	19.0	-	45.1	83.2	51.3	60.1	61.3	71.8	397.3
0.1	33.9	16.0	-	26.1	5.9	-	-	4.4	4.3	90.6
254.2	40.7	63.7	-	135.7	109.8	65.6	-	152.9	9.5	577.9
5.5	56.2	77.4	-	107.7	102.7	4.6	-	22.4	29.2	400.2
7.0	8.2	18.7	-	54.9	7.7	23.6	-	3.8	5.1	122.0
3.1	7.2	0.4	-	24.4	24.4	40.2	-	11.9	3.6	112.1
55.3	156.8	6.8	-	26.4	20.8	18.4	-	5.6	25.8	260.6
57.9	6.5	0.7	-	31.1	47.8	68.4	48.4	13.6	11.9	228.4
252.7	293.2	40.1	-	89.5	55.5	128.5	-	18.4	87.9	713.1
118.6	515.0	21.3	-	15.3	5.5	-	-	1.0	-	558.1
4.0	16.3	11.8	-	44.4	53.4	6.4	31.9	7.6	7.6	179.4
136.3	11.1	57.1	-	33.3	35.6	16.0	-	6.9	43.2	203.2
4.5	9.3	0.4	-	15.3	27.7	18.7	-	4.7	3.6	79.7
29.6	74.7	66.5	-	84.3	52.4	62.0	80.3	38.7	4.6	463.5
-	0.8	3.9	-	10.2	13.1	-	-	0.6	-	28.6
23.8	1.8	5.2	-	58.2	39.1	53.1	59.4	29.9	17.9	264.6
24.6	-	8.4	-	50.0	21.1	4.1	-	25.7	4.1	113.4
0.1	5.4	23.4	-	46.7	1.3	35.4	-	17.0	23.1	572.6
0.4	1.7	4.5	-	39.1	56.8	64.8	7.9	12.8	7.4	195.0
12.8	46.5	11.7	-	17.2	12.7	23.3	-	2.3	30.0	143.7
84.9	7.9	42.8	-	87.1	167.4	153.3	105.4	83.3	14.0	661.2
215.6	5.2	3.7	-	141.2	65.1	77.9	66.6	19.5	32.2	351.4
74.1	57.8	12.3	-	75.8	15.0	10.3	33.0	99.7	23.2	327.1
22.7	134.3	3.4	-	52.1	36.8	10.5	20.2	22.9	13.9	294.1
32.0	11.6	3.4	-	3.1	18.1	-	-	1.4	-	331.7

MM20: Type P, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
109.4	62.8	-	-	-	10.1	-	-	-	-	-
26.5	53.5	0.4	-	-	-	-	-	-	-	-
31.4	18.8	-	-	-	-	-	-	-	-	-
34.1	52.8	17.0	-	-	-	-	-	-	-	-
67.5	44.0	8.1	-	-	1.4	-	-	-	-	-
76.4	25.4	-	-	-	1.6	-	-	-	-	-
17.5	50.6	3.7	-	-	-	-	-	-	-	-
52.5	34.6	25.3	0.6	-	1.1	-	-	-	2.5	-
32.9	31.1	14.0	-	-	-	-	-	-	-	-
34.6	20.5	1.2	-	-	-	-	-	-	-	-
63.4	63.1	4.3	-	-	4.1	-	-	-	-	-
27.4	42.5	12.1	-	-	-	5.5	-	-	-	-
68.8	29.3	19.7	-	-	-	-	-	-	-	-
51.2	47.5	1.9	-	-	3.4	-	-	-	-	-
114.8	66.4	30.3	-	-	0.2	-	-	-	-	-
22.7	25.6	0.3	-	-	-	-	-	-	-	-
42.4	33.5	-	-	-	-	2.2	-	-	1.3	-
31.2	67.0	2.1	-	-	-	-	-	-	-	-
61.6	17.5	0.1	-	-	0.2	-	-	-	-	-
116.2	16.5	-	-	-	-	-	-	-	-	-
67.5	32.2	-	-	-	-	-	-	-	-	-
101.5	25.0	-	-	-	4.6	-	-	-	-	-
114.7	42.2	-	-	-	13.7	-	-	-	0.5	-
32.0	31.5	3.4	-	-	2.1	-	-	-	2.9	-
74.4	70.7	2.3	-	-	2.7	-	-	-	-	-

Appendix 6.26

MM20: Type P, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
10.1	2.5	62.4	-	17.5	20.5	8.1	-	5.5	49.3	165.8
0.4	13.4	3.0	-	4.3	2.4	-	-	17.7	7.4	48.2
-	14.3	2.2	-	6.7	37.4	12.5	-	5.3	-	78.4
17.0	47.6	0.6	-	12.8	4.5	-	-	37.0	22.7	102.5
9.5	49.4	-	-	4.7	0.7	-	-	0.5	-	55.3
1.6	16.5	27.5	-	21.3	22.2	-	-	12.3	11.1	110.9
3.7	35.1	1.1	-	10.1	7.5	26.9	-	7.7	-	88.4
29.5	15.8	0.5	-	0.7	-	-	-	2.8	-	19.8
14.0	32.6	0.2	-	11.3	21.4	12.3	46.2	25.3	-	149.3
1.2	19.2	2.5	-	26.4	15.5	19.3	-	12.2	2.8	97.9
8.4	34.0	3.4	-	11.3	14.4	30.2	-	115.5	5.7	214.5
17.6	26.8	-	-	0.3	4.5	-	-	-	-	31.6
19.7	17.9	2.0	-	5.1	-	-	-	73.7	-	98.7
5.3	5.9	1.3	-	13.8	1.5	-	-	2.0	13.6	38.1
30.5	29.2	0.1	-	9.4	15.8	-	-	2.6	1.4	143.1
0.3	12.3	-	-	1.3	23.3	85.6	-	0.9	-	123.4
3.5	34.3	8.4	-	16.1	11.5	18.5	-	11.4	-	100.2
2.1	50.2	2.5	-	9.3	7.3	-	10.1	4.7	-	84.1
0.3	1.0	0.3	-	1.1	1.1	-	-	1.5	-	5.0
-	0.1	1.5	-	5.2	14.2	41.8	-	5.3	-	68.1
-	0.7	0.2	-	3.4	17.4	20.3	11.6	20.2	5.4	79.2
4.6	5.3	4.7	-	3.8	15.1	3.8	-	14.2	-	46.9
14.2	0.3	1.0	-	17.4	29.6	-	-	0.3	-	48.6
8.4	12.2	18.7	-	26.8	15.9	1.8	-	3.4	-	78.8
5.0	37.4	1.3	-	4.3	1.4	-	14.2	6.0	3.6	54.0

MM20: Type 0, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
148.6	46.1	5.7	1.6	-	16.8	-	-	-	-	-
139.2	42.3	24.6	3.1	-	7.3	-	-	-	-	-
166.4	43.1	3.3	3.5	-	0.4	-	-	-	-	-
164.1	30.5	0.6	4.9	-	15.8	-	-	-	-	-
109.6	17.0	6.5	3.4	-	12.4	4.9	-	-	-	-
174.5	34.9	14.3	1.0	-	1.3	-	-	-	-	-
228.3	20.4	-	0.5	-	14.9	-	-	-	-	-
84.1	17.6	12.0	4.9	-	5.4	-	-	-	2.4	-
138.5	121.7	4.4	0.3	-	-	-	-	-	-	-
127.4	66.9	0.9	0.6	-	1.9	-	-	-	-	-
128.8	106.2	6.4	0.5	-	0.2	-	-	-	-	-
63.0	21.1	1.5	-	-	-	-	-	-	-	-
120.5	36.3	-	-	-	3.8	-	-	-	-	-
90.2	4.6	20.4	-	-	0.3	-	-	-	-	-
77.5	40.0	-	-	-	-	-	-	-	-	-
103.2	5.0	24.8	-	-	-	-	-	-	-	-
70.1	72.5	0.5	-	-	-	-	-	-	-	-
128.0	21.6	11.8	0.1	-	9.3	2.3	-	-	-	-
82.1	49.4	10.5	0.2	-	0.1	-	22.8	-	-	-
69.5	21.6	2.7	0.3	-	4.7	-	-	-	-	-
5.8	8.7	1.2	-	-	-	-	-	-	-	-
62.5	17.0	4.7	0.1	-	16.2	10.8	7.7	-	-	-
54.8	20.4	68.8	-	-	-	-	-	-	-	-
57.6	49.4	2.6	0.4	-	-	-	-	-	2.2	-
154.9	67.2	3.8	-	-	-	-	-	-	-	-

MM20: Type O, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
24.1	19.8	75.3	-	23.0	-	5.1	49.6	-	-	172.8
35.0	15.3	21.6	-	5.7	-	-	-	0.1	-	42.7
7.2	9.5	29.0	-	5.9	0.3	26.8	-	36.3	-	107.8
21.3	3.5	32.6	-	11.7	18.7	3.6	12.5	2.9	-	73.0
27.2	9.7	22.2	-	7.8	12.9	-	-	0.7	-	53.3
16.6	12.0	9.7	-	6.1	-	-	-	0.1	-	27.9
15.4	0.3	65.7	-	2.8	-	-	-	1.3	-	70.1
24.7	20.2	40.0	-	6.3	-	-	-	5.5	-	72.0
4.7	5.4	9.9	-	3.9	-	-	28.7	-	-	47.9
3.4	16.1	25.2	-	2.2	2.2	-	-	-	-	45.7
7.1	17.5	1.6	-	18.6	12.2	2.5	-	-	6.0	52.4
1.5	2.4	1.7	-	1.9	5.1	1.4	-	3.7	-	16.2
3.8	3.3	6.1	-	6.5	4.8	-	45.2	1.7	-	67.6
20.7	9.1	7.4	-	3.3	-	-	-	0.6	-	20.4
-	8.2	14.3	-	2.5	1.4	1.8	-	-	-	28.2
24.8	20.5	8.8	-	3.4	4.0	5.2	-	-	-	41.9
0.5	11.4	1.2	-	6.8	-	3.1	-	2.1	-	24.6
23.5	14.8	45.6	-	8.1	3.3	-	-	19.1	11.0	101.9
33.6	37.4	6.2	-	16.3	11.4	31.2	7.1	0.5	-	110.1
7.7	30.6	23.0	-	6.7	5.6	20.2	-	7.9	15.1	109.1
1.2	1.0	1.2	-	-	-	-	-	2.4	-	4.8
39.5	3.5	50.2	-	22.2	2.5	6.6	-	0.2	-	85.2
68.8	18.2	1.6	-	11.0	11.5	17.5	25.1	5.9	1.2	92.0
5.2	35.4	29.4	-	1.9	8.9	40.5	-	13.5	-	129.6
3.8	24.8	4.5	-	5.3	0.4	15.6	37.8	0.4	-	88.8

T02: Type P, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
20.8	32.6	47.5	-	-	-	-	-	-	-	-
61.3	32.6	13.4	-	-	3.2	-	-	-	-	-
143.3	114.8	52.2	8.1	-	3.3	-	-	-	-	0.6
200.8	72.6	290.5	-	-	-	-	-	-	-	-
8.5	13.6	4.8	0.1	-	-	-	-	-	-	-
4.2	8.5	253.4	-	-	-	-	-	-	-	-
15.6	25.4	0.4	-	-	-	-	-	-	-	-
40.1	23.7	0.3	-	-	7.7	-	-	-	-	-
5.4	16.3	0.6	-	-	10.3	1.1	-	-	0.6	-
93.4	17.5	68.6	-	-	-	-	-	-	-	-
125.1	16.5	4.7	0.1	-	8.5	-	-	-	-	-
0.5	22.3	0.3	-	-	-	-	-	-	-	-
0.3	7.3	-	-	-	-	1.3	6.1	-	81.6	-
55.4	11.6	40.6	0.9	-	-	-	-	-	-	-
156.8	8.3	12.6	-	-	0.7	-	-	-	-	-
42.0	3.2	-	-	-	0.1	-	-	-	-	-
8.2	22.1	0.6	-	-	0.3	-	-	-	0.6	-
1.6	17.2	0.5	-	-	-	-	-	-	-	-
89.0	24.5	75.8	0.1	-	-	3.8	-	-	3.9	-
23.8	3.9	11.3	-	-	-	-	-	-	-	-
76.0	19.1	6.8	-	-	-	-	-	-	-	-
111.7	74.0	86.8	-	-	-	-	-	-	-	-
-	-	-	-	-	-	11.5	-	-	-	-
63.3	3.2	0.6	0.2	-	17.7	-	-	-	-	-
8.7	7.8	2.6	-	-	-	-	-	-	-	-

TO2: Type P, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
47.5	17.5	5.4	-	3.6	20.2	-	81.4	3.7	-	131.8
16.6	42.1	13.9	-	2.7	4.4	-	22.4	1.0	2.1	66.2
64.2	81.0	20.2	-	9.9	-	-	8.6	0.3	4.6	124.6
290.5	106.2	-	-	2.2	-	-	16.3	-	-	124.7
4.9	6.7	4.5	-	8.4	8.1	1.5	-	7.6	7.2	44.0
253.4	110.7	1.5	-	2.5	-	-	7.9	0.2	-	122.8
0.4	15.6	-	-	-	-	-	-	-	-	15.6
8.0	6.3	17.3	-	17.9	27.1	42.2	9.6	0.3	12.3	133.0
12.6	22.5	37.2	-	24.0	-	43.3	-	21.5	-	148.5
68.6	17.5	0.8	-	-	-	-	-	-	-	18.3
13.3	40.7	7.6	-	12.2	14.5	-	54.3	1.8	9.6	140.7
0.3	109.9	0.7	-	9.2	-	-	13.6	6.9	-	140.3
89.0	8.2	13.1	-	4.8	5.6	9.9	-	46.8	-	88.4
41.5	21.7	3.0	-	0.2	-	-	-	0.3	-	25.2
13.3	10.8	54.9	-	9.1	8.4	2.6	-	6.8	-	92.6
0.1	4.5	24.5	-	6.5	-	-	-	0.4	-	35.9
1.5	3.7	9.2	-	14.5	7.6	2.7	53.5	8.1	2.2	101.5
0.5	16.2	10.0	-	5.7	3.9	50.7	-	6.8	4.5	97.8
83.6	41.6	44.0	-	22.2	27.2	-	21.5	19.2	5.5	181.2
11.3	4.6	7.2	-	12.5	-	55.5	-	0.8	-	80.6
6.8	18.7	2.0	-	8.0	-	-	-	-	-	28.7
86.8	61.8	1.6	-	0.8	0.8	3.1	-	1.2	-	69.3
11.5	-	13.2	-	7.9	-	2.8	-	5.4	6.6	35.9
18.5	-	56.2	-	6.0	-	-	-	6.0	-	68.2
2.6	-	29.6	-	15.9	4.2	35.4	128.6	14.8	-	228.5

TO2: Type O, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
162.1	36.0	28.9	0.1	-	0.3	-	-	-	3.1	-
33.0	19.5	49.9	-	-	-	-	-	-	-	-
66.4	9.5	20.8	-	-	0.2	-	-	-	-	-
3.7	33.0	1.2	-	-	-	-	-	-	-	-
147.1	13.6	179.8	-	-	-	-	-	-	-	-
149.8	23.4	9.6	1.4	-	3.8	-	-	-	-	-
63.6	17.6	27.2	-	-	-	-	-	-	-	-
34.3	27.5	81.4	-	-	-	-	-	-	-	-
266.6	9.1	-	-	-	106.8	36.2	40.2	-	-	-
150.7	22.1	154.5	-	-	-	-	-	-	0.4	-
73.8	29.8	46.1	0.1	-	-	-	-	-	-	-
21.9	6.7	27.4	-	-	-	-	-	-	-	-
17.8	15.7	0.8	-	-	2.8	-	-	-	-	-
107.8	7.5	44.7	-	-	-	-	-	-	-	-
90.0	28.9	34.3	-	-	-	-	-	-	-	-
25.2	15.9	69.9	-	-	-	-	-	-	4.8	-
3.6	19.5	1.0	-	-	0.3	-	-	-	24.6	-
105.0	19.3	33.9	-	-	5.3	-	-	-	8.2	-
117.2	8.5	15.1	-	-	-	-	-	-	-	-
10.3	0.2	81.8	-	-	-	-	-	-	-	-
33.1	11.8	12.6	-	-	4.5	-	-	-	10.8	-
73.0	11.3	32.0	-	-	18.5	-	-	-	-	-
70.6	5.4	54.6	0.1	-	-	-	-	-	-	-
61.0	20.7	4.9	1.4	-	13.9	-	-	-	14.7	-
44.2	24.5	7.6	-	-	-	-	-	-	-	-

Appendix 6.32

TO2: Type O, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
32.4	45.6	23.7	-	22.3	26.6	14.8	26.6	22.0	18.1	223.4
49.9	36.6	12.9	-	-	-	-	-	0.3	-	49.8
21.0	73.9	6.5	-	2.4	8.8	11.7	-	7.8	-	111.1
1.2	53.8	6.0	-	9.1	7.4	-	-	31.0	8.4	115.7
179.8	106.4	2.5	-	-	4.2	-	-	19.1	-	132.2
14.8	67.5	4.7	-	-	-	-	-	-	-	72.2
27.2	32.9	7.8	-	2.8	-	-	-	-	-	43.5
81.4	8.3	8.0	-	20.8	1.8	7.8	-	0.4	2.6	49.7
183.2	15.4	12.1	-	9.6	-	-	-	0.1	10.6	47.8
154.9	255.4	4.1	-	0.8	-	-	-	0.2	-	260.5
46.2	63.2	35.4	-	5.9	14.5	-	-	0.2	-	119.2
27.4	88.5	3.8	-	2.0	-	-	-	1.4	-	95.7
3.6	26.5	1.3	-	3.6	-	-	-	0.5	-	31.9
44.7	107.5	30.7	-	6.4	-	-	-	5.7	-	150.3
34.3	29.5	0.1	-	-	-	-	-	0.1	-	29.7
74.7	65.4	3.1	-	9.4	-	11.6	6.1	4.5	-	100.1
25.9	5.9	9.2	-	18.0	1.5	-	-	2.2	13.8	50.6
47.4	16.1	51.2	-	12.2	-	-	-	9.4	-	88.9
15.1	11.8	1.6	-	-	-	-	-	0.5	-	13.9
81.8	63.1	1.2	-	-	-	-	-	-	-	64.5
27.9	45.9	2.6	-	34.3	20.6	22.1	19.8	39.1	13.3	197.7
50.5	66.7	-	-	0.7	9.7	-	-	0.1	3.3	80.5
54.7	42.8	3.8	12.3	6.6	-	35.6	14.2	4.1	-	119.4
34.9	23.1	1.8	-	6.5	-	-	35.4	2.0	-	68.8
7.6	14.7	12.3	-	5.0	4.0	-	-	3.4	-	39.4

T056: Type D/O, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
75.6	54.2	48.5	-	-	-	17.3	-	-	2.4	-
25.4	5.4	54.2	-	-	-	-	-	-	-	-
109.8	50.1	51.7	-	-	3.5	-	-	-	-	-
3.5	0.3	0.7	6.2	-	39.6	14.1	-	-	-	-
41.1	1.3	61.8	-	-	-	-	-	-	-	-
65.6	25.3	152.3	-	-	-	-	-	-	-	-
27.9	17.5	55.2	-	-	-	-	-	-	-	-
24.2	6.2	65.7	-	-	-	-	-	-	-	-
30.1	11.1	140.1	-	-	-	-	-	-	-	-
-	1.1	58.2	0.1	-	-	-	-	-	-	-
48.7	27.6	109.7	-	-	3.5	-	-	-	0.1	-
4.3	1.4	32.6	-	-	-	-	-	-	-	-
67.7	12.5	4.5	0.1	-	-	-	-	-	0.3	-
166.5	65.2	7.6	0.1	-	2.1	7.0	12.0	-	4.9	-
96.4	27.2	10.6	-	-	0.5	-	-	-	-	-
60.4	10.5	16.6	-	-	3.4	-	-	-	-	-
35.2	7.8	55.4	-	-	-	-	-	-	-	-
44.9	19.5	-	-	-	2.5	25.9	32.7	-	0.5	-
46.1	17.5	13.0	-	-	-	-	-	-	-	-
36.8	12.4	56.6	0.3	-	1.2	-	-	-	-	-
58.0	47.4	19.7	0.1	-	-	-	-	-	0.1	-
322.7	19.2	-	-	-	-	-	-	-	-	-
75.6	11.1	7.8	-	-	0.6	-	-	-	0.1	-
47.2	7.4	40.1	-	-	0.7	-	-	-	-	-
58.8	39.4	53.8	-	-	0.2	-	-	-	-	-

Appendix 6.34

T056: Type D/O, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
68.2	110.6	1.5	-	1.2	3.1	-	22.7	0.2	-	139.3
54.2	66.1	13.5	-	-	-	-	-	-	-	79.6
55.2	10.0	12.6	-	8.2	14.3	-	-	9.2	4.9	59.2
60.6	-	59.1	-	57.1	19.4	3.4	-	19.0	-	158.0
61.8	24.7	1.3	-	-	-	-	-	0.1	-	26.1
152.5	65.9	2.2	-	7.6	-	-	-	0.7	7.7	84.1
55.2	188.8	1.2	-	1.2	1.0	-	-	6.7	-	198.9
65.7	56.2	1.5	-	14.8	2.6	2.6	27.3	1.9	-	106.9
140.1	89.9	6.6	-	7.7	9.3	-	-	14.6	20.9	149.0
58.3	36.9	4.8	-	7.7	8.6	15.2	66.5	4.9	5.3	149.9
113.3	67.2	0.8	-	4.2	9.7	-	-	7.3	2.7	91.9
32.6	67.9	1.5	-	16.2	21.0	30.5	84.8	1.0	8.2	235.0
4.9	248.7	2.2	-	9.8	10.3	-	-	0.7	17.4	289.1
33.7	61.9	2.1	-	9.4	3.2	9.8	13.7	2.0	7.3	109.4
11.1	82.6	3.8	-	2.1	-	-	-	4.4	3.6	96.5
20.0	81.9	0.5	-	36.4	24.2	91.7	19.4	17.8	24.5	296.4
55.4	29.7	9.6	-	0.5	-	-	-	1.3	-	41.1
61.6	2.6	10.4	-	24.9	28.5	-	-	48.5	1.9	116.8
13.0	22.0	14.6	-	8.6	21.8	-	-	21.0	4.7	92.7
58.1	72.7	23.4	-	4.6	1.7	15.1	-	3.2	12.0	132.7
19.9	28.6	24.3	-	14.1	2.2	-	-	4.6	-	73.8
-	4.1	3.6	-	6.2	3.6	30.1	-	0.3	-	47.9
8.5	3.2	9.3	-	21.3	18.0	-	-	1.1	-	52.9
40.8	119.4	4.3	-	3.7	11.4	10.6	-	0.7	-	150.1
54.0	117.8	3.1	-	-	1.1	-	-	0.1	4.1	126.2

T056: Type D/O, Treatment UB; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
17.8	5.8	23.2	-	-	-	-	-	-	-	-
173.3	162.3	24.7	-	-	-	-	-	-	-	-
44.4	34.8	43.0	-	-	4.8	-	-	-	-	-
67.9	38.7	58.3	-	-	-	-	-	-	-	-
287.2	0.3	-	-	-	46.9	-	-	-	-	-
28.1	1.6	16.5	-	-	-	-	-	-	-	-
1.5	1.9	11.6	-	-	-	-	-	-	-	-
120.3	0.1	60.6	0.5	-	-	-	-	-	-	-
26.9	0.4	2.7	-	-	32.5	5.1	-	-	-	-
17.5	4.2	37.7	0.1	-	0.7	-	-	-	-	-
124.4	8.5	-	-	-	-	-	-	-	-	-
12.6	1.5	93.0	-	-	1.5	-	-	-	-	-
30.7	15.5	2.8	-	-	-	-	-	-	-	-
45.8	46.7	37.0	-	-	-	-	-	-	-	-
31.3	14.9	13.1	-	-	5.8	-	-	-	-	-
23.8	26.1	50.9	-	-	-	-	-	-	-	-
84.6	39.0	25.8	0.2	-	-	-	-	-	-	-
46.2	26.8	26.4	-	-	-	-	-	-	-	-
24.9	3.5	21.5	-	-	3.6	0.9	-	44.7	3.8	-
71.0	29.9	17.0	-	-	5.4	15.4	-	-	-	-
18.5	3.0	43.2	-	-	-	-	-	-	-	-
43.4	13.2	27.8	-	-	-	-	-	-	-	-
255.8	20.9	22.7	0.1	-	16.0	-	-	-	-	-
54.3	3.7	64.0	-	-	12.5	-	-	-	-	-
29.4	4.1	0.4	0.1	-	112.1	20.1	23.3	-	11.4	-

T056: Type D/O, Treatment UB; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
23.2	24.7	-	-	7.4	12.4	14.3	-	-	5.8	64.6
24.7	41.7	8.7	-	15.5	12.2	8.7	-	0.4	13.2	100.4
47.8	103.4	8.5	-	58.9	18.3	-	32.2	2.6	19.6	243.5
58.3	108.7	2.9	-	-	10.3	38.7	-	1.1	6.1	167.8
56.5	1.3	60.1	-	70.9	5.8	34.6	-	-	5.3	184.1
16.5	70.0	14.0	-	23.0	16.3	2.4	23.1	6.8	15.0	208.6
11.6	119.8	62.3	-	56.3	24.6	9.7	13.7	29.6	15.9	359.5
40.3	12.3	38.0	-	141.0	65.4	187.2	195.1	80.4	35.3	754.7
40.3	10.0	18.7	-	56.0	19.5	19.2	13.9	4.7	7.1	149.1
38.5	51.7	3.2	-	15.1	9.2	20.2	82.1	0.4	15.1	197.0
-	26.1	42.1	-	13.2	-	38.2	-	0.1	11.9	131.6
94.5	112.2	21.0	-	39.8	21.1	83.9	113.7	2.4	22.5	416.6
2.8	20.6	9.0	-	8.1	18.2	8.4	-	3.5	2.8	70.6
37.0	115.9	7.0	-	1.6	18.2	3.8	-	0.2	-	146.7
18.9	71.0	18.1	-	38.5	13.3	54.0	-	12.1	19.3	327.9
50.9	123.3	33.7	-	7.8	3.8	-	-	14.8	9.9	193.3
26.0	97.1	40.4	-	5.5	1.0	-	23.6	0.2	40.7	221.1
26.4	117.2	.3.8	-	7.1	10.6	-	16.2	9.8	15.5	80.2
125.9	11.8	9.4	-	16.8	5.4	56.1	-	91.1	18.8	209.4
37.8	102.4	48.9	-	24.5	9.2	-	-	4.4	17.1	207.4
43.2	149.3	6.8	-	34.9	24.5	71.4	57.2	11.0	37.6	392.7
27.8	66.3	10.7	-	5.6	5.7	66.6	-	16.7	4.7	176.3
38.8	1.8	62.4	-	86.6	18.3	25.8	-	9.1	46.1	250.1
76.5	19.6	66.5	-	13.2	0.6	13.9	-	5.2	27.5	146.5
167.4	32.4	18.1	-	45.7	14.2	26.6	8.0	43.7	33.6	222.3

T030: Type D/O, Treatment B; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
73.0	11.9	45.9	-	-	-	5.7	-	-	-	-
80.6	13.3	58.9	0.1	-	0.8	1.9	-	-	-	-
65.8	16.9	41.7	0.1	-	-	-	-	-	-	-
12.7	1.7	22.9	-	-	-	-	-	-	-	-
51.8	15.5	5.8	-	-	-	-	-	-	-	-
106.3	11.4	5.7	-	-	-	-	-	-	-	-
38.3	5.2	3.3	-	-	-	-	-	-	-	-
35.1	4.2	23.3	-	-	-	-	-	-	-	-
13.0	1.7	138.3	-	-	-	-	-	-	-	-
81.1	11.4	83.2	-	-	-	-	-	-	-	-
57.8	9.4	120.3	-	-	9.4	7.4	2.8	-	-	-
28.5	20.7	21.0	-	-	0.6	10.1	-	-	-	-
54.2	8.5	15.8	-	-	11.4	-	-	-	-	-
93.8	42.2	-	-	-	0.2	12.4	-	-	0.2	-
249.6	23.0	0.1	-	-	0.2	11.0	-	-	-	-
209.6	30.4	28.0	-	-	-	-	-	-	-	-
2.8	4.9	2.4	-	-	53.4	3.5	-	-	-	-
134.5	29.3	-	-	-	17.2	-	-	-	-	-
49.2	3.5	21.6	-	-	-	-	-	-	-	-
93.5	7.0	73.8	-	-	0.2	-	-	-	-	-
191.2	20.3	9.6	0.4	-	3.1	-	-	-	-	-
86.3	4.4	-	2.1	-	49.1	-	-	-	-	-
278.4	9.5	48.9	-	-	22.2	-	-	-	-	-
122.2	3.4	16.2	-	-	3.3	-	-	-	-	-
73.9	1.7	142.0	-	-	-	-	-	-	-	-

T030: Type D/O, Treatment B; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
51.6	21.4	3.3	-	5.0	2.1	-	-	1.4	-	33.2
61.7	49.1	1.1	-	4.7	9.0	4.5	-	0.4	-	68.8
41.8	25.6	1.4	-	-	0.7	2.3	-	0.5	-	30.5
22.9	15.4	2.3	-	4.7	4.3	-	-	2.5	13.4	42.6
5.8	18.8	3.1	-	4.9	-	3.7	-	6.4	6.8	36.9
5.7	11.7	2.3	-	1.8	4.0	-	-	-	-	19.8
3.3	2.4	3.7	-	3.6	-	12.1	4.0	0.1	-	25.9
23.3	12.8	3.9	-	6.2	-	-	-	0.8	-	23.7
138.3	37.1	46.9	-	11.3	4.1	-	-	3.0	8.4	110.8
83.2	102.2	2.0	-	6.0	-	-	-	0.7	25.0	135.9
139.9	55.6	1.6	-	33.3	18.7	25.1	-	77.4	6.8	223.2
31.7	66.0	19.4	-	24.3	6.3	9.8	28.4	138.2	20.3	312.7
27.2	42.3	17.8	13.9	6.4	-	-	-	-	14.5	94.9
13.0	43.7	22.0	-	6.1	2.2	2.9	-	1.0	-	78.0
11.3	9.3	69.6	-	6.4	-	-	-	-	-	85.4
28.0	21.6	6.2	-	5.6	3.3	11.6	-	-	1.3	49.6
59.3	5.5	0.4	-	59.6	3.5	6.4	-	0.2	-	75.6
17.2	15.9	34.5	-	22.4	7.6	16.4	-	1.1	18.0	115.9
21.6	44.7	15.3	-	9.9	-	8.6	-	0.1	14.8	93.4
74.0	85.5	1.1	-	1.0	-	-	-	0.3	19.2	107.1
13.1	18.3	15.2	-	1.5	11.8	22.2	-	5.5	24.4	122.4
51.2	1.0	141.5	-	36.1	-	-	-	18.8	54.3	251.7
71.1	24.6	28.1	-	5.7	16.1	-	-	2.1	18.3	94.9
19.5	83.9	56.4	-	7.0	0.6	-	-	56.6	-	204.5
142.0	21.5	27.7	-	3.0	-	-	-	1.4	4.7	58.3

T030: Type D/O, Treatment UB; 1982/83

A/GL	GL	ADV	ALE	ALI	AT1	AT2	AT3	AT4	AB	AMF
96.5	2.9	-	-	-	11.7	-	-	-	-	-
91.9	11.4	-	0.2	-	11.4	-	-	43.6	1.2	-
61.3	11.6	-	2.2	-	12.6	13.5	21.9	-	-	-
29.3	0.8	3.4	-	-	-	-	-	-	-	-
141.5	29.5	79.1	-	-	3.8	-	-	-	1.6	-
246.8	40.6	0.3	-	-	27.7	-	-	-	2.9	-
73.3	156.9	-	-	-	22.6	-	-	-	-	-
-	-	-	-	-	-	-	33.1	-	12.1	-
28.6	0.8	12.7	-	-	-	13.4	-	-	-	-
150.8	16.3	18.3	0.2	-	39.5	14.7	-	16.2	0.5	72.3
41.3	0.7	-	-	-	14.3	2.7	-	-	-	-
28.3	50.8	3.9	-	-	9.5	-	-	-	0.5	-
31.2	3.4	-	-	-	10.3	12.2	10.5	-	-	-
85.3	44.3	-	-	-	47.1	-	-	-	86.6	-
105.9	16.2	90.5	0.9	-	0.5	-	-	-	-	-
132.4	2.7	53.5	1.0	-	11.4	6.0	-	-	-	-
136.6	60.5	-	-	-	10.7	-	-	-	1.0	-
155.3	54.9	16.3	111.3	-	83.1	27.7	4.9	-	11.4	-
14.7	0.2	2.4	-	-	16.6	-	-	33.4	3.5	-
59.0	0.2	16.5	-	-	28.8	7.5	-	-	4.3	-
19.2	1.2	36.6	0.1	-	19.2	8.3	4.0	-	48.5	-
168.3	5.7	113.3	0.1	-	-	-	-	-	-	-
17.8	17.6	51.6	-	-	6.6	4.5	-	-	0.6	-
79.9	18.2	1.2	0.3	-	3.5	5.5	11.9	24.5	0.1	-
13.7	1.6	23.4	0.4	-	44.9	21.6	-	-	-	-

T030: Type D/O, Treatment UB; 1982/83

AGDT	GDV	GLE	GLI	GT1	GT2	GT3	GT4	GB	GMF	GDT
11.7	1.3	19.3	-	48.5	19.6	43.3	14.2	61.4	121.7	329.3
56.4	9.6	24.6	-	45.3	26.0	-	-	44.8	83.8	257.2
50.2	-	12.9	-	48.1	15.7	18.3	31.1	6.1	48.9	181.1
3.4	10.2	6.5	-	15.5	-	4.8	17.7	1.6	-	56.3
84.5	243.3	8.6	-	15.3	35.1	20.8	-	0.3	45.5	368.9
30.9	11.1	55.2	-	81.3	54.0	67.3	9.1	25.4	75.2	378.6
22.6	0.7	16.3	1.4	26.8	1.2	23.3	-	2.0	34.2	110.6
45.2	-	15.8	-	277.4	110.8	176.9	-	97.3	109.6	795.6
26.1	-	17.6	-	140.8	15.4	27.1	32.9	8.7	72.3	314.8
161.7	16.0	57.7	-	72.1	12.0	19.9	-	11.2	75.0	288.2
17.0	2.4	17.0	-	17.5	4.4	7.1	-	-	13.0	61.4
13.9	2.5	45.3	-	33.8	33.7	28.6	-	25.4	52.2	258.1
33.0	5.1	32.4	-	32.8	5.6	27.7	11.4	14.4	15.3	192.9
133.7	1.1	56.2	-	43.8	17.3	14.0	-	57.5	64.3	254.2
91.9	80.5	26.6	-	15.3	1.6	-	-	5.4	20.7	151.6
71.9	9.9	17.4	-	24.7	18.3	30.3	-	0.6	15.7	116.9
11.7	0.6	58.5	-	41.7	40.7	56.1	-	19.1	0.8	217.5
154.7	2.0	2.3	-	49.8	38.9	40.8	-	1.7	-	135.5
55.9	5.4	13.5	-	158.1	36.3	82.7	74.2	16.0	49.4	435.6
57.1	19.2	13.1	-	30.5	2.5	3.1	-	8.0	42.5	118.9
116.7	20.4	28.4	-	75.0	43.1	72.1	26.1	75.5	172.0	512.6
113.4	81.8	10.2	-	10.6	8.5	40.4	-	49.2	42.7	247.6
63.3	51.5	118.8	-	36.4	23.9	-	77.5	9.4	35.2	352.7
47.0	0.9	6.4	-	8.7	2.3	2.6	68.1	7.6	8.9	105.5
90.3	8.4	45.8	-	73.0	4.5	3.8	-	26.5	17.7	179.7

APPENDIX 7: The dates of the bird censuses undertaken at MM14 during 1983 and 1984, together with descriptions of the prevailing weather conditions.

DATE OF CENSUS	WEATHER CONDITIONS
12/4/83	Clear skies. Very light breeze. Warm.
5/7/83	Clear skies. Calm. Cool-warm. (Previous 10 days severe frosts and snow.)
3/8/83	Clear skies. Very light breeze. Cold.
10/9/83	Intermittent light cloud. Light northerly breeze. Cool-warm. (Previous 5 days almost constant rain.)
5/10/83	95% cloud cover. Light southerly breeze. Cool.
30/11/83	100% cloud cover. Strong northerly breeze. Cool-warm.
3/1/84	30% to 100% cloud cover. Strong southwesterly breeze. Cool.
7/2/84	10% cloud cover. Moderate northerly breeze. Cool-warm.
1/3/84	95% cloud cover. Very light breeze. Cold-cool following heavy rain.
3/4/84	5% cloud cover. Light westerly breeze. Warm.
2/5/84	Clear skies. Calm. Cold-cool.
19/6/84	100% cloud cover. Calm. Cold.
12/7/84	30% to 100% cloud cover. Calm. Cold-cool.
9/8/84	100% cloud cover. Moderate northerly breeze. Cool.
13/9/84	100% cloud cover (light high altitude cloud). Light northeasterly breeze. Cool-warm.
8/10/84	100% cloud cover. Strong northerly breeze. Cool-warm.
14/11/84	15% cloud cover. Moderate southeasterly breeze. Cool-warm following heavy rain.

APPENDIX 8: Bird species observed at MM14 during the years 1981-1984. Nomenclature follows Schodde et al.(1977).

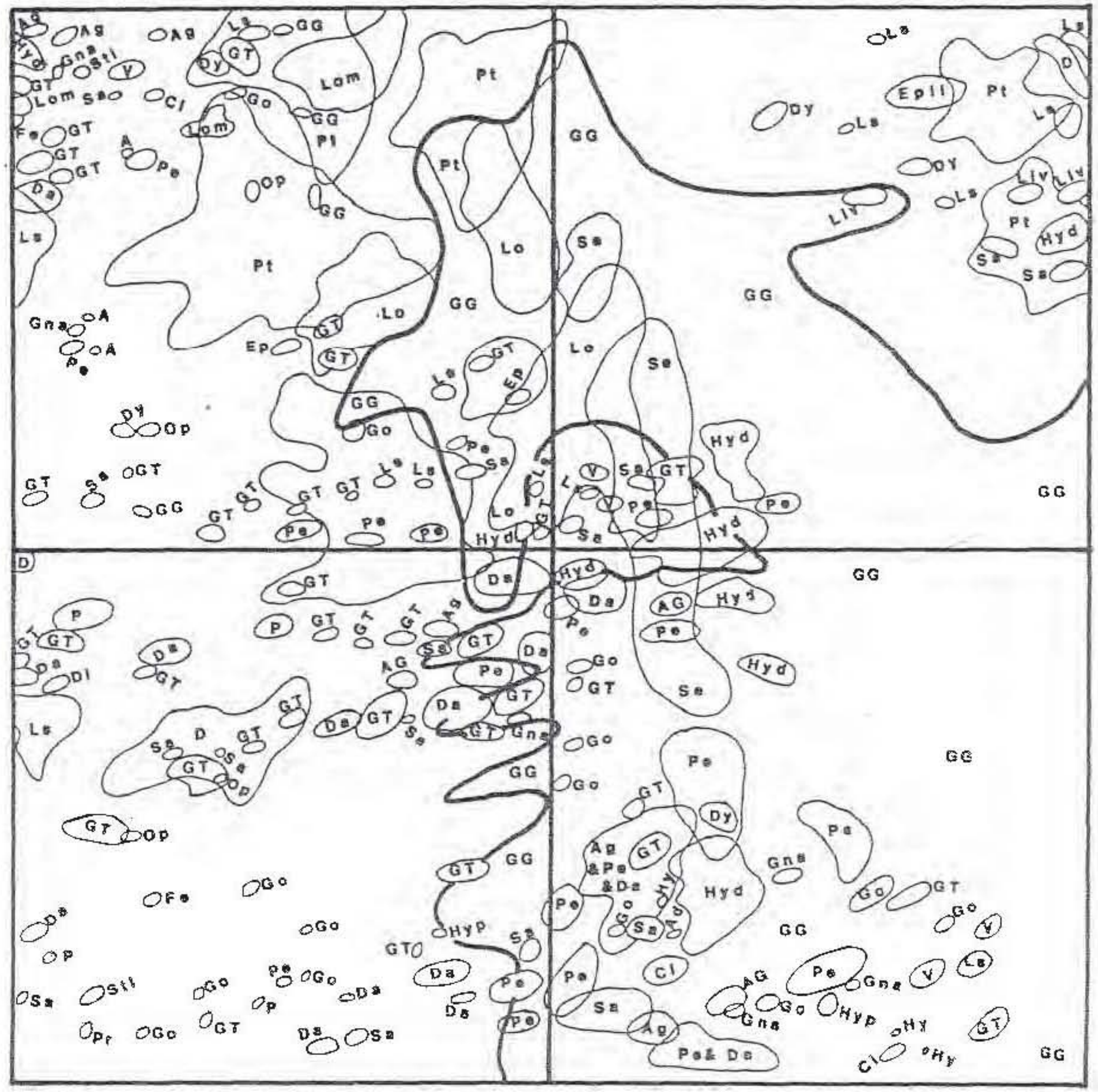
* = species endemic to Tasmania.

Wedge-tailed Eagle	Aquila audax
Brown Falcon	Falco berigora
Common Bronzewing	Phaps chalcoptera
Brush Bronzewing	Phaps elegans
Yellow-tailed Black-Cockatoo	Calyptorhynchus funereus
Swift Parrot	Lathamus discolor
*Green Rosella	Platycercus caledonicus
Blue-winged Parrot	Neophema chrysostoma
Pallid Cuckoo	Cuculus pallidus
Fan-tailed Cuckoo	Cuculus pyrrhophanus
Shining Bronze-Cuckoo	Chrysococcyx lucidus
White-throated Needletail	Hirundapus caudacutus
Laughing Kookaburra	Dacelo novaeguineae
Skylark	Alauda arvensis
Welcome Swallow	Hirundo neoxena
Tree Martin	Cecropis nigricans
Black-faced Cuckoo-shrike	Coracina novaehollandiae
White's Thrush	Zoothera dauma
Flame Robin	Petroica phoenicea
Scarlet Robin	Petroica multicolor
*Dusky Robin	Melanodryas vittata
Olive Whistler	Pachycephala olivacea
Golden Whistler	Pachycephala pectoralis
Grey Shrike-thrush	Colluricincla harmonica
Satin Flycatcher	Myiagra cyanoleuca
Grey Fantail	Rhipidura fuliginosa
Spotted Quail-thrush	Cinclosoma punctatum
Superb Fairy-wren	Malurus cyaneus
White-browed Scrub-wren	Sericornis frontalis
Calamanthus	Sericornis fuliginosus
Brown Thornbill	Acanthiza pusilla
*Tasmanian Thornbill	Acanthiza ewingii
Yellow-rumped Thornbill	Acanthiza chrysorrhoa
*Yellow Wattlebird	Anthochaera paradoxa
*Yellow-throated Honeyeater	Lichenostomus flavicollis
*Strong-billed Honeyeater	Melithreptus validirostris
*Black-headed Honeyeater	Melithreptus affinis
Crescent Honeyeater	Phylidonyris pyrrhoptera
New Holland Honeyeater	Phylidonyris novaehollandiae
Eastern Spinebill	Acanthorhynchus tenuirostris
Spotted Pardalote	Pardalotus punctatus
Striated Pardalote	Pardalotus striatus
Silvereye	Zosterops lateralis
European Goldfinch	Carduelis carduelis
Beautiful Firetail	Emblema bella
Dusky Woodswallow	Artamus cyanopterus
Grey Butcherbird	Cracticus torquatus
*Black Currawong	Strepera fuliginosa
Grey Currawong	Strepera versicolor
Forest Raven	Corvus tasmanicus

TRANSPARENCY 1

Fig. 5 (b)

JAN. 1984



TRANSPARENCY 2

Fig. 5 (d)

JAN. 1984

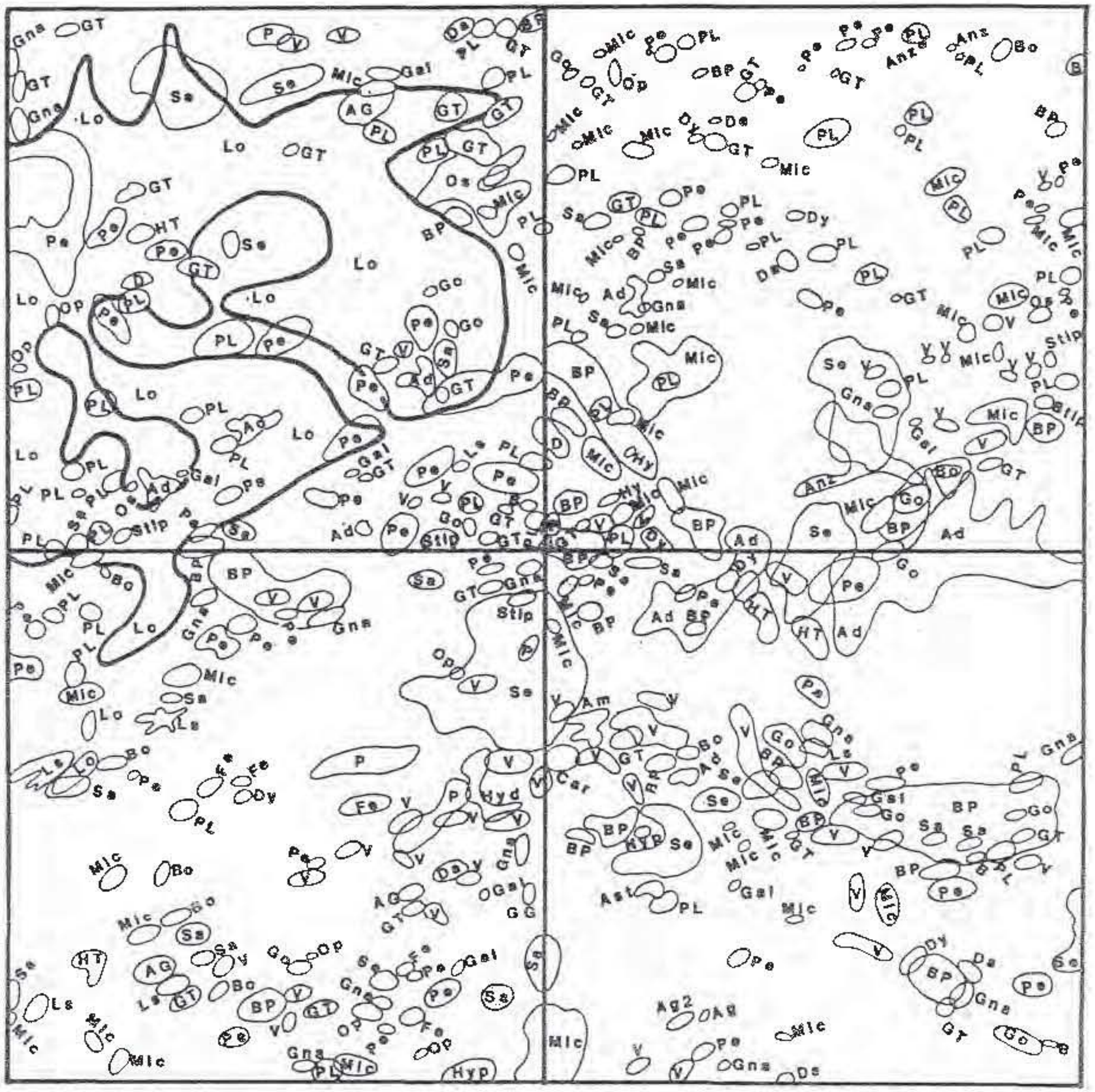
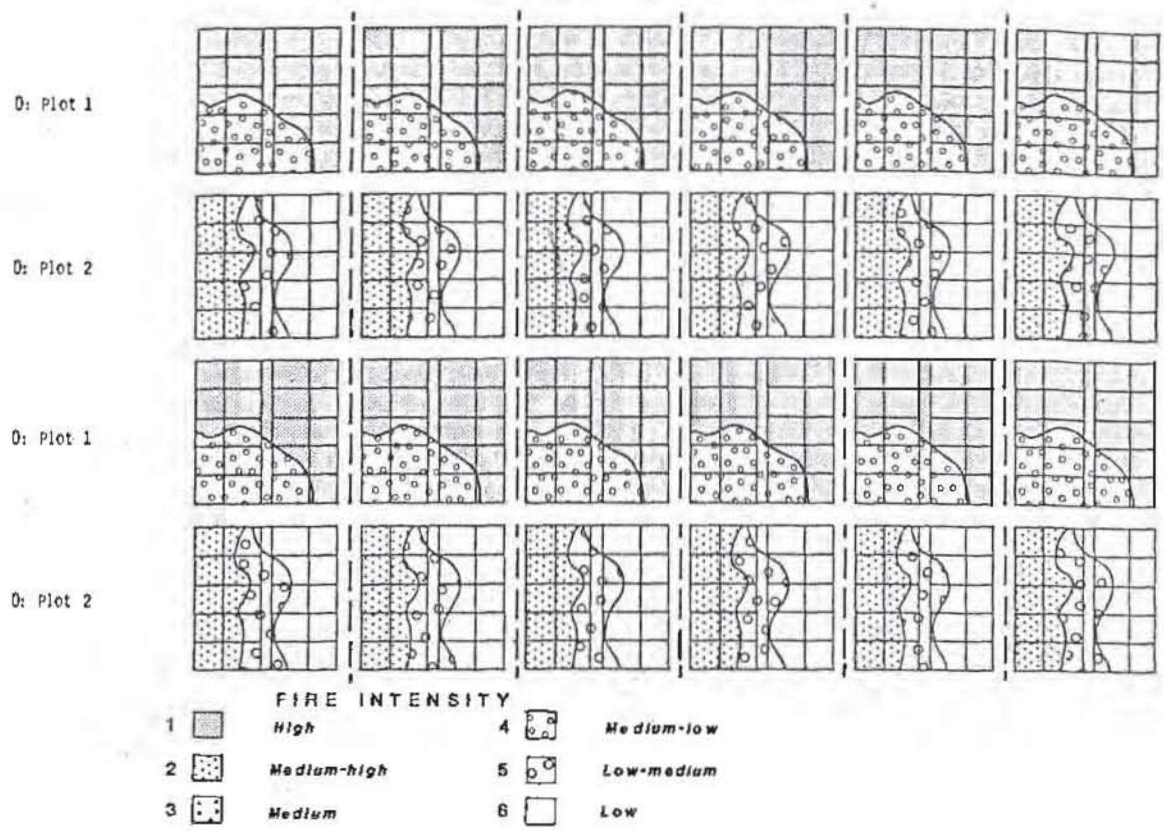
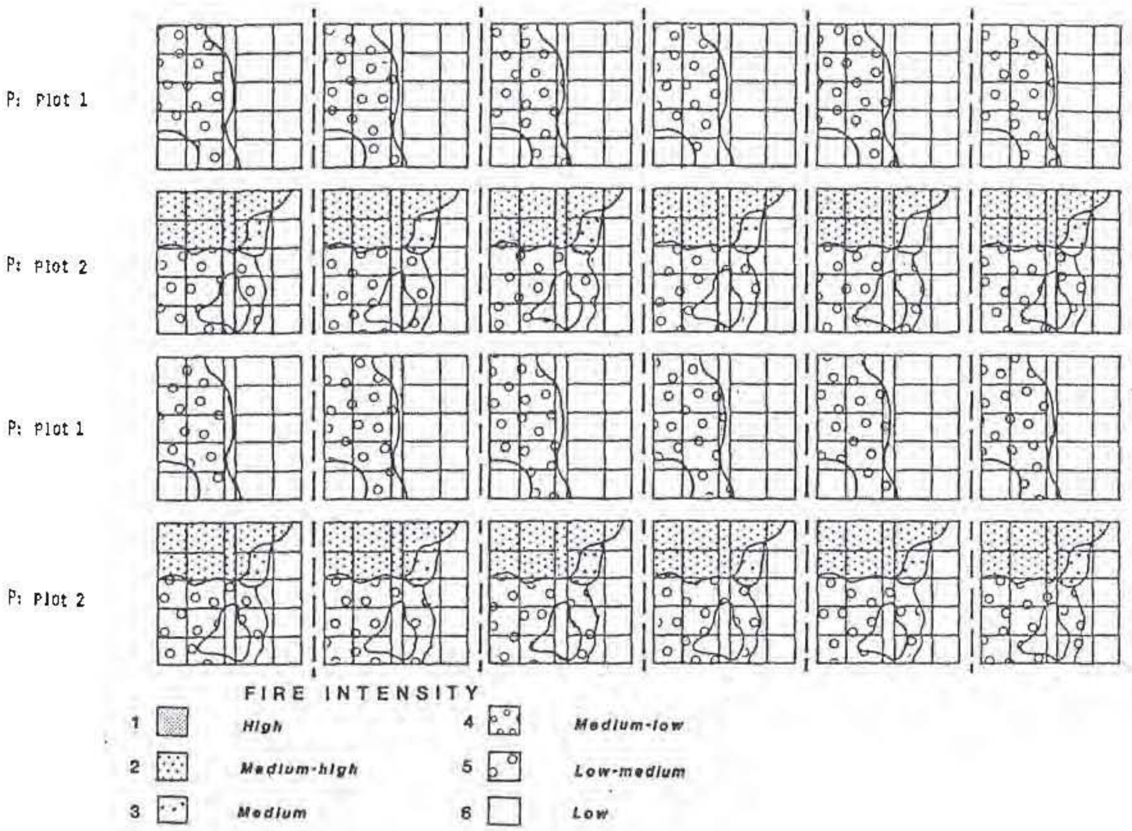


Fig. 16 (1)   TYPE Q: - PATTERN OF FIRE INTENSITY CLASSES



TRANSPARENCY 3

Fig. 16 (m) TYPE P: - PATTERN OF FIRE INTENSITY CLASSES



TRANSPARENCY 4